PRODUCTIVITY DYNAMICS: U.S. MANUFACTURING PLANTS, 1972-1986*

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Abstract

This paper presents an analysis of the dynamics of total factor productivity measures for large plants in SICs 35, 36, and 38. Several TFP measures, derived from production functions and Solow type residuals, are computed and their behavior over time is compared, using various non-parametric tools. Aggregate TFP, which has grown substantially over the time period, is compared with average plant level TFP, which has declined or remained flat. Using transition matrices, the persistence of plant productivity is examined, and it is shown how the transition probabilities vary by industry, plant age, and other characteristics.

Keywords

Total Factor Productivity, Transition Dynamics, Large Manufacturing Plants

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1 Introduction and Summary

This paper describes the results of investigations into the dynamics of total factor productivity (TFP) in large manufacturing plants from 1972 through 1986. We try to answer fundamental questions regarding the movement of plants within the cross sectional distribution of productivity, as time progresses: If productivity in the aggregate improves, does that mean that the constituent plants (for this aggregate) share, nearly uniformly, in this improvement? Does plant level productivity improve steadily over time? Do plants move up or down the productivity rank in discrete jumps? Is there a tendency for plants to converge, in their productivity characteristics, either towards the best or worst practice plants, or towards the mean? We present evidence on nearly all of these issues, viz., aggregate versus (plant) average productivity behavior, and productivity transitions over time, identifying some general plant characteristics that help explain the observed movements.

While this study is not entirely novel, indeed one may point to many antecedents in which productivity behavior at the aggregate or plant level has been examined it is, in many ways, quite distinctive. The difference, relative to (aggregate) industry-wide level studies, is readily apparent. Some recent studies analyze productivity behavior from a macro-economic perspective: Papers by Bartelsman (1991), and Bartelsman, Caballero, and Lyons (1991), which are a reaction to a paper by Hall (1988) and its finding of strikingly high returns to scale, employ aggregate time series at the two-, and four-digit level; moreover, they focus on the existence of "linkage" and "spillover" effects, as an explanation of the returns to scale phenomenon highlighted by Hall. More directly concerned with productivity behavior is the comprehensive study of productivity growth at the economy-wide level by Jorgenson *et al.* (1987). Their work is quite different in orientation and purpose from ours. They operate with aggregate annual economy-wide data over the period 1948-1979, as well as with annual time series on 51 constituent sectors. Their objective is to assess the effect on aggregate rates of output growth, of the growth of factor inputs, of the "quality" of factor inputs and a time trend which they call productivity, in the context of a translog production framework. They attempt to construct indices of the quality of the input so that aggregate results and weighted averages of sectoral results on productivity become compatible. This is forced upon them because they insist on working with an aggregate production relation, as well as the sectoral production relations.

While our data are at the plant level, we share certain aggregate insights with Jorgenson *et al.*, viz., that what we call productivity does, in part, reflect the skill and equipment mix of the labor and capital inputs respectively. In Jorgenson *et al.* this aspect is removed more or less arbitrarily by the use of translog indices reflective of various measured attributes of the labor force or of the capital stock. In our case this is allowed to manifest itself through variations in total factor productivity. The fact that aggregation issues may be an important consideration in the measurement of TFP we had discovered at an earlier stage of this research, Dhrymes (1991), viz., that (two-digit) industry-wide productivity, and its growth over time, may be "reduced" considerably once the four digit industry composition of the sample is acknowledged.

What is established in this work is the distinction between improvement in technology, or productivity, at the plant level, abstracting from resource re-allocation between plants, and improvement at the aggregate level due to resource re-allocation from relatively inefficient to relatively efficient plants.

Recent studies, Dhrymes (1990), (1991), Gort *et al.* (1991), Griliches and Regev (1991), Nguyen and Kokkelenberg (1991), and Tybout (1990), among others, also use plant level data to study productivity issues. The methodologies used in these studies have in common the estimation of a production technology using standard regression analysis. Dhrymes (1990) is concerned with industry heterogeneity and with the sensitivity of results to functional form. Further, as a precursor to the work presented here, Dhrymes (1991) tracks the cross sectional distribution of the productivity residual over time, and establishes the fact of dynamic transitions in the TFP ranking of plants. Nguyen and Kokkelenberg are also concerned with the measurement of TFP, and present estimates of rates of return to R&D spending, based on three alternate calculations of TFP. Gort estimates production functions both in levels and in percent changes, and rationalizes differences in parameter estimates as the result of productivity interactions between investment flows and capital vintage. Tybout calculates TFP and returns to scale measures using plant level data for a group of developing countries. He estimates both cost and production functions and compares the parameter estimates for compatibility or mutual consistency, as was done in Dhrymes (1990).

In this study, we take some of the TFP measures as calculated in Dhrymes (1991), and observe their dynamic behavior. We show, in the broadest possible context, that the movement, over time, of the productivity residual of plants, from one decile to another is subject to transitional probabilities. This process acts constantly to alter the cross sectional distribution of productivity residuals. We also examine, using the framework of discrete time Markov chains, the influence of various factors on the probability of increasing, decreasing, or leaving unaffected, one's productivity rank, conditional on initial rank. On issues related to the use of transitional probabilities see Singer and Spilerman (1976); for a different type of application, see Quah (1990). As we show, certain plant characteristics, such as age, can increase both the probability of improving and worsening productivity; this effect would not have been easy to detect in a standard regression analysis of productivity in its relation to age.

The conclusions of our study are almost as rich as the data on which the results are based. First, we find that the (unweighted) mean of plant TFP experiences sustained and nearly uniform decline over the period 1972-1984, with a definite upturn in 1984-86. This is true whether one examines the Cobb-Douglas (CD) derived measure of TFP, or the Corrected Solow Residual (CSR) derived measure, exhibited in Figs. 1 and 2, respectively. On the other hand, with either of the two measures noted above, at the aggregate (two digit industry) level, TFP shows a dip through the early seventies and a sustained growth thereafter. This finding indicates the possibility that plants may indeed never improve their productivity, but that "good" plants may expand operation, or highly productive plants start operations, while "bad" plants may shrink or cease to exist. It is shown that new plants do not enter predominantly at the high end of the productivity spectrum, and that the probability of changing productivity rank within the cross section, both upwards and downwards, is higher for the youngest plants than for older plants. Average plant size also decreases the probability of moving up or down in the productivity distribution. The transition probabilities, and productivity rankings, vary widely by industry, but overall, there is a large degree of persistence in productivity ranking; about 60 percent of the plant-year observations do not move more than one decile away from their present rank. We also corroborate earlier findings (Dhrymes 1991) that Solow residual type measures of TFP are "smoother" than production function based TFP measures.

The organization of the paper is as follows: Section two discusses the various measures of TFP analyzed in this paper, and contrasts aggregate productivity growth with the growth of mean plant-level productivity. The next section discusses some theoretical aspects of transition matrices and presents the estimated matrices. The following sections describe tabulations of TFP rankings and TFP transitions broken down by industry, age and size.

2 Plant vs. Aggregate Productivity: Aggregation Illusion or Fact?

The data underlying this research are based on the Census' Longitudinal Research Data (LRD) file for "large plants" in three two-digit SIC industries.[1] Observations on such plants are available on an annual basis; indeed, the sample includes all such (large manufacturing) plants, so that what we have is, actually, the entire population of large plants in industries 35, 36 and 38. From such data we obtain various measurements of productivity. More specifically, from large plants in each industry, over the period 1972-1986, we estimate a production function (Cobb-Douglas as well as translog results are given) allowing for time (year) effects, as well as four digit industry effects. Evaluating the estimated function at the relevant arguments corresponding to plant i at time t, we determine Z_{ti}, which is the contribution to output by the enumerated inputs (which include capital, production and nonproduction labor, and may include any "time" or "four digit" industry effects). If Q_{ti} is the output of plant i at time t then

$$\frac{Q_{ti}}{Z_{ti}} = TFP_{ti},$$

TFP standing for total factor productivity, which is simply the "residual", or the contribution to output of technical change, in the literature of the sixties. In addition to Cobb-Douglas and translog based TFP, (denoted by CD and TL respectively), we have also produced a measure of TFP based on the pre-econometric literature, see e.g., Solow (1957). In his original contribution, Solow obtained the logarithmic derivative of the production function $Q_t = A(t)F(x)$, viz.,

$$\frac{\dot{Q}_{ti}}{Q_{ti}} = \frac{\dot{A}_i(t)}{A_i(t)} + \sum_{j=1}^{n} \frac{\partial Q_{ti}}{\partial x_{tij}} \frac{x_{tij}}{Q_{ti}} \frac{\dot{x}_{tij}}{x_{tij}}.$$

[1] Large plants are defined by the Census to be those employing more than 250 employees. The industries analyzed are: Machinery, except Electrical (35), Electrical and Electronic Machinery, Equipment, and Supplies (36), and Measuring, Analyzing and Controlling Instruments (38). A more complete description of the data may be found in Dhrymes (1990). The size distribution of plants, by the magnitude of the number of employees, is given in Graphs A1 through A4, in the appendix. What appears to be an odd occurrence, viz., the presence of plants employing less than 250 employees is explicable as follows: Census makes a determination of membership in its Large Plant sample (LPS) on the Census years; thereafter, such plants are carried in the sample for the next five years until a new Census year arrives. Those plants that may have ceased to qualify for membership in the LPS are now dropped, and the new membership is determined. But this means that the LP sample may well contain plants employing fewer than 250 workers, to the extent that loss of qualification has occurred in the period intervening between Census years.

If one assumes a **perfectly competitive** theory of distribution, $(\frac{\partial Q_{ti}}{\partial x_{tij}}\frac{x_{tij}}{Q_{ti}})$ is simply the (observed) share of output (of the i^{th} plant) accruing to the j^{th} factor, at time t. Moreover, exhaustion of output means that the shares add up to one; it is then almost an implication. that the underlying production function is homogeneous of degree one. Solow obtained the (ordinate of the) technical change function by "integrating" the term $\frac{\dot{A}_i(t)}{A_i(t)}$, thus obtaining what has come to be known as total factor productivity (TFP). Note, further that if shares are taken to be nearly constant, integration of the relation above yields,

$$\ln Q_{ti} \approx \ln A_i(t) + \left(\sum_{j=1}^{n} s_{tij} \ln x_{tij}\right),$$

which argues that the function F "ought" to be of the Cobb-Douglas variety. In the context in which Solow was writing, and with the aggregat- data he considered (GNP), the virtual constancy of factor shares appeared to be an empirical reality. Thus, the practice of determining TFP by

$$\ln TFP_{ti} = \ln\left(\frac{Q_{ti}}{Z_{ti}}\right), \quad \ln Z_{ti} = \sum_{j=1}^{n} s_{tij} \ln x_{tij},$$

had a certain cachet of authority. In subsequent times, the rationalization was altered to the interpretation that what one was constructing by Z_{ti} is a certain "index of total inputs" and what was termed earlier "the residual", or the "Solow residual", became known as **total factor productivity (TFP)**.

Whether one posits *ab initio* the (plant) production function

$$Q_{ti} = A_i(t)F(x), \quad \text{with} \quad F(x) = \prod_{j=1}^{n} x_{tij}^{\alpha_j},$$

or one indirectly employs it, in effect, via the "total factor index" is a matter of research strategy, and on: of relatively minor import, although gross disparities in the empirical implications of the two procedures may well force a choice. In our approach we take, for each two digit industry,

$$\ln A_i(t) = \sum_{s=1}^{m} \beta_s d_{s1} + \sum_{\tau=1}^{T} \gamma_\tau d_{\tau 2} + \pi(i), \tag{1}$$

where the d_{s1} are "dummy" variables assuming the value one, if the plant in question belongs in the s^{th} four digit industry and zero otherwise and the $d_{\tau 2}$ are also dummy variables assuming the value one if the observation is in year τ and zero otherwise; finally, $\pi(i)$ is the "productivity component", of the factor $A_i(t)$. If we state the production function, in stochastic form, as

$$\ln Q_{ti} = \sum_{s=1}^{m} \beta_s d_{s1} + \sum_{r=1}^{T} \gamma_r d_{r2} + \pi(i) + \sum_{j=1}^{n} \alpha_j \ln x_{tij} + u_{ti},$$

where u_{ti} is the stochastic component of the production relation, we may define, more fully, the contribution to output by the enumerated factors as

$$\ln Z_{ti} = \sum_{s=1}^{m} \beta_s d_{s1} + \sum_{r=1}^{T} \gamma_r d_{r2} + \sum_{j=1}^{n} \alpha_j \ln x_{tij}, \tag{2}$$

and thus TFP would be defined by

$$\ln TFP_{ti} = \ln\left(\frac{Q_{ti}}{Z_{ti}}\right) = \pi(i) + u_{ti}. \tag{3}$$

If, for the purposes of the very basic analysis of this paper, we endow the stochastic component with the simplest of properties, viz., that it is independent, identically distributed (i.i.d.) with mean zero and positive variance, the relation in Eq. (3) represents the TFP process of the i^{th} plant, as a "noisy" variant of the productivity process, $\pi(i)$, even if all other underlying parameters are known. If not, then additional uncertainty is present, whether we apply an econometric procedures in estimating such parameters, or whether we resort to pre- or non-econometric procedures. In the econometric procedures we shall employ, we estimate the underlying parameters, the α's, β's, γ's, and, on that basis, obtain the entities in Eq. (3). It is this entity, or its antilog that we term the CD based (or TL based if the translog production function is used) measure of productivity. A similar construction is involved in the Solow residual, or the corrected Solow residual (CSR) based measure of plant productivity. Given the entities Q_{ti} and Z_{ti}, we can construct aggregate measures

$$Q_t = \sum_{i=1}^{N} Q_{ti}, \quad Z_t = \sum_{i=1}^{N} Z_{ti}, \quad TFP_t = \frac{Q_t}{Z_t}.$$

In this context, (Q_{ti}/Z_{ti}) defines the trajectory of TFP for an individual plant, while (Q_t/Z_t) defines the trajectory of TFP for the industry in question. Of course, since we are only dealing with large plants our "industry" measure amounts to about 60% to 80% of the appropriate (two digit) industry total; the remaining 20% to 40% is accounted for by the activities of (small) nonlarge plants. We reiterate that the usual Solow residual differs from that of the CD or TL based TFP in that the former does not take into account (i.e., it **includes**) time (year) and industry (four digit industry) effects. The remedy employed is to remove these effects by regression and to deal with the residual of that regression. This is termed the **corrected Solow residual** based measure of TFP. The entities TFP_{ti}, however derived, are the basic subject of the analysis to follow.

In the major studies alluded to in the previous section there has been little effort expended on the analysis of how productivity growth takes place, beyond the stylized manner in which productivity is incorporated in the neoclassical production framework, under the guise of technical change. In that context, when applied (typically) to two digit industries the impression is created that the "representative" plant experiences "neutral" technical change in the sense that, over time, the frontier of its production function is propelled outward by forces that improve productivity, or induce "technical change", more or less uniformly across plants. The issue of heterogeneous productivity behavior by plants in the same industry has not been seriously addressed.

This issue, however, may be easily analyzed at a rather elementary level by means of Figures 1 and 2, which contain productivity information regarding all three industries (35, 36 and 38) in the form of CD-derived and CSR-derived TFP, respectively. The solid line graphs the function $\ln(Q_t/Z_t)$, i.e., $\ln TFP_t$ based on the weighted CD, CSR residuals, the weights being (Z_{ti}/Z_t). The broken line graphs the function

$$\ln\left[\frac{1}{N}\sum_{i=1}^{N}\left(\frac{Q_{ti}}{Z_{ti}}\right)\right] = \ln\overline{TFP}_t.$$

If one looks at the graph of aggregate productivity, one would gain the impression of substantial growth, about 24% since 1974, if one uses the CD-derived measure of TFP, or 12% since 1976, if one uses the CSR measure. In either case, the annual rate of growth is of the order of 1.2% to 2.0%. The (CD-derived TFP) plant mean graph, on the other hand, traces a continual decline until 1984, declining at the rate of about .75% per annum, and an increase in 1985 and 1986. In the case of CSR-based TFP, the plant mean graph traces a more or less sustained decline through 1982, at about the rate of .6% per annum, and thereafter experiences a considerable increase.[2] How can we rationalize or explicate these two disparate trajectories? We begin by

[2] A careful examination of the data shows that the substantial productivity increase in the middle 80's

Fig. 1

Cobb-Douglas Residual

Aggregate and Mean

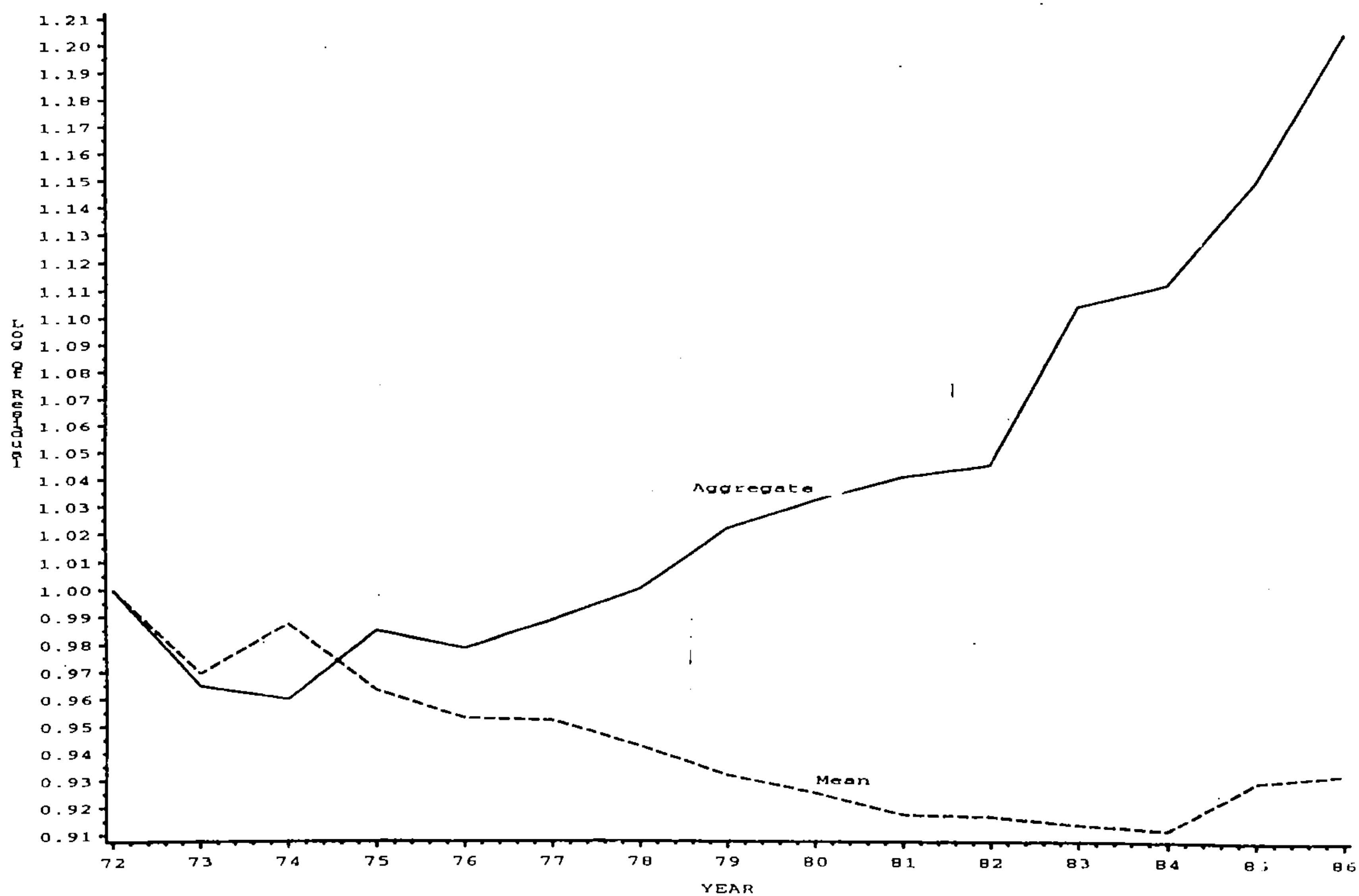
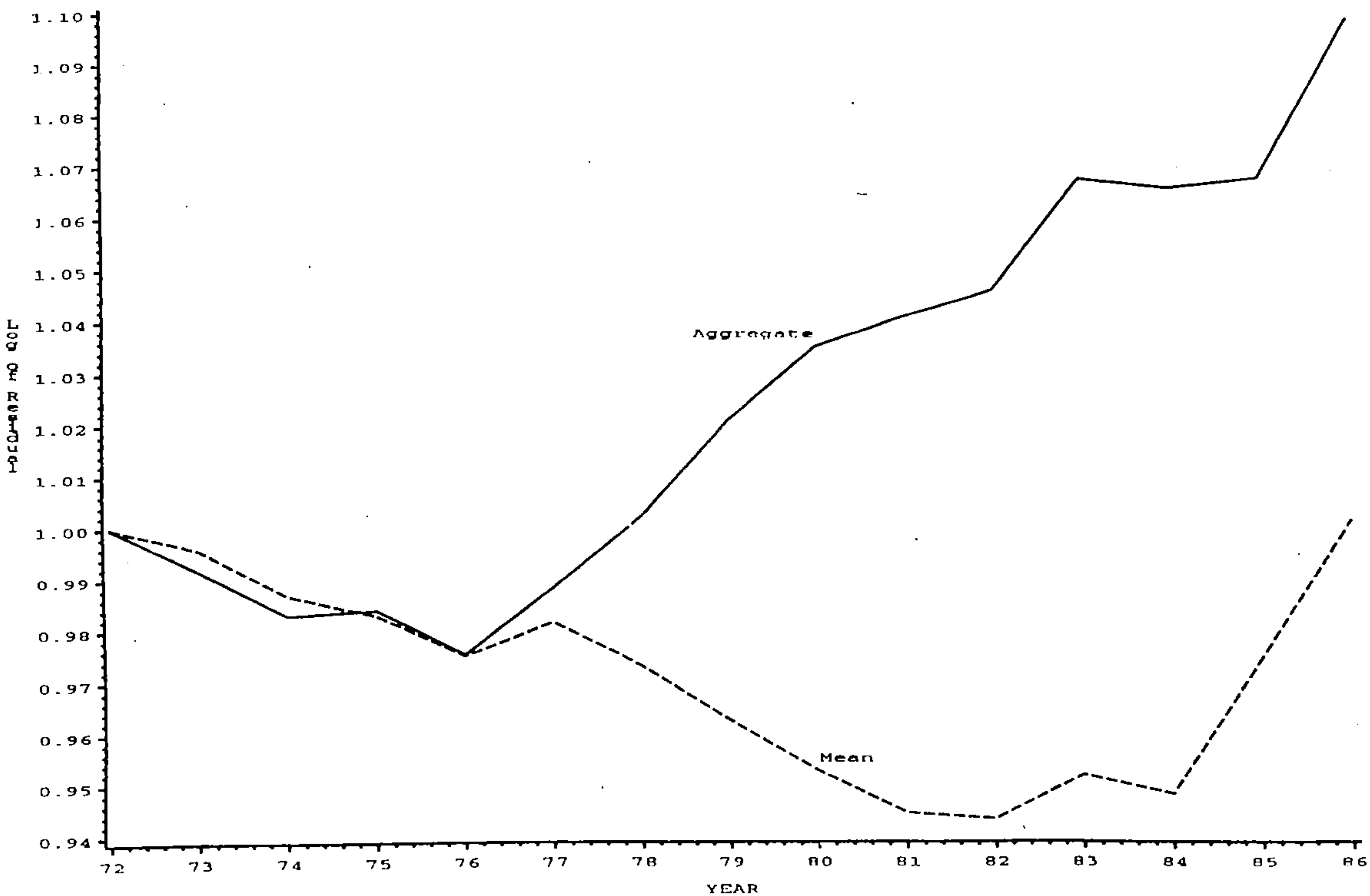


Fig. 2

Corrected Solow Residual

Aggregate and Mean



noting that

$$\frac{Q_t}{Z_t} = \frac{\sum_{i=1}^{N} Q_{ti}}{Z_t} = \sum_{i=1}^{N} \left(\frac{Q_{ti}}{Z_{ti}}\right)\left(\frac{Z_{ti}}{Z_t}\right), \tag{4}$$

thus exhibiting aggregate productivity as a weighted sum of plant TFP. If we think of the mean graph as representing the logarithm of the simple (unweighted) average and of the aggregate graph as representing the logarithm of the weighted arithmetic mean, the two graphs would coincide if either (Z_{ti}/Z_t) were constant with respect to t and i, or if TFP_{ti} were constant across all plants and all time periods. On the other hand if $(Z_{ti}/Z_t) = a_i$, is a constant across time periods, but not across plants then the two graphs would display the pattern if, on balance, the larger plants had growing TFP, while the smaller plants had declining TFP. Alternatively, if TFP_{ti} were constant over time, but not across plants, then the the displayed pattern would be consistent with the contribution (to Z_t) of "efficient" plants increasing over time. We will shortly see, however, that plant level productivity is very persistent, and that plants do not easily change their position within the cross sectional productivity distribution. In other words, we would observe aggregate improvements in productivity not because the "representative" plant has experienced productivity growth but rather because resources are being reallocated over time from less to more productive plants. That this reallocation results, by 1986, in an aggregate productivity improvement of about 25% is nothing less than remarkable!

3 Productivity Transitions

An important issue in the analysis of productivity behavior is whether plants occupy a fixed rank in terms of their productivity aspects, so that the notion of the "representative plant" is useful, or whether their rank is subject to continuous variation. Short of actually examining each individual plant, which would be cumbersome, a promising way of looking at this problem is through the device of productivity transitions. To lay the foundation for this aspect of the paper, consider the probability space $(\Omega, \mathcal{A}, \mathcal{P})$, where Ω is the sample space, $\mathcal{A}$ is the σ-algebra of subsets and $\mathcal{P}$ is the probability measure. On this space define

coincides with the change in the manner in which the price index for certain "high tech" industries is constructed. We should also point out that, while details may differ appreciably, the broad conclusion that the path of "aggregate productivity" is quite different from the path of mean plant productivity remains valid whether we consider the individual industries 35, 36 or 38, separately, or whether we pool them, as we did in Graphs 1 and 2, of the text.

$X_t : \Omega \rightarrow \{1, 2, \ldots, 10\}, \quad t = 1, 2, \ldots.$

which is the process (stochastic sequence) assigning deciles (to plants) at "time" t. By definition, X_t is a discrete random variable and, as such, has the representation

$$X_t(\omega) = \sum_{j=1}^{10} j I_{tj}(\omega), \tag{5}$$

where I_{tj} is the indicator function of the set

$$D_{tj} = \{\omega : X_t(\omega) = j\}, \tag{6}$$

i.e., $I_{tj}(\omega) = 1$ if $\omega \in D_{tj}$ and zero otherwise. We note that the collection of sets,

$$\mathcal{D}_t = \{D_{tj} : j = 1, 2, \ldots, 10\}, \tag{7}$$

is a (finite) partition of the space (Ω), induced by the random variable X_t. In this context, we wish to study the probability structure of $X_{t+\tau}$, $\tau = 0, 1, 2, \ldots$, given X_t. Thus, consider the partition induced by $X_{t+\tau}$

$$\mathcal{D}_{t+\tau} = \{D_{t+\tau,j} : j = 1, 2, 3, \ldots, 10\}. \tag{8}$$

We ask: what do we wish to mean by the conditional probability of one of the sets of the partition above, say $D_{t+\tau,j}$, given the partition $\mathcal{D}_t$? Or, what is equivalent, given the realization X_t? Clearly, the result is a random variable which, when evaluated at a point $\omega \in D_{ts}$ yields $\mathcal{P}(D_{t+\tau,j} \mid D_{ts})$. Consequently, we have the representation

$$\mathcal{P}(D_{t+\tau,j} \mid \mathcal{D}_t) = \mathcal{P}(D_{t+\tau,j} \mid X_t) = \sum_{s=1}^{10} \mathcal{P}(D_{t+\tau,j} \mid D_{ts}) I_{ts}(\omega). \tag{9}$$

Moreover, it follows that

$$E(X_{t+\tau} \mid X_t) = \sum_{j=1}^{10} j \mathcal{P}(D_{t+\tau,j} \mid X_t) = \sum_{j=1}^{10} j \left(\sum_{s=1}^{10} \mathcal{P}(D_{t+\tau,j} \mid D_{ts}) I_{ts}(\omega) \right). \tag{10}$$

From the fact that

$$E\left[E(X_{t+\tau} \mid X_t)\right] = E(X_{t+\tau}) = \sum_{j=1}^{10} j\mathcal{P}(D_{t+\tau,j}), \tag{11}$$

we conclude

$$\mathcal{P}(D_{t+\tau,j}) = \sum_{s=1}^{10} \mathcal{P}(D_{t+\tau,j} \mid D_{ts})\mathcal{P}(D_{ts}), \quad j = 1, 2, \ldots, 10. \tag{12}$$

Putting

$$x_t = \begin{pmatrix} \mathcal{P}(D_{t1}) \\ \mathcal{P}(D_{t2}) \\ \cdots \\ \mathcal{P}(D_{t10}) \end{pmatrix} \quad A_{t+\tau} = [\mathcal{P}(D_{t+\tau,i} \mid D_{tj})], \quad i, j = 1, 2, \ldots, 10, \tag{13}$$

we have the representation

$$x_{t+\tau} = A_{t+\tau} x_t. \tag{14}$$

This is an identity between the marginal probabilities at time $t + \tau$ and those at time t, via the conditional probabilities that are the elements of $A_{t+\tau}$.

Two issues arise in connection with Eq. (14): first, is the transition process (essentially the matrix $A_{t+\tau}$) time homogeneous and, second, is the transition process Markovian? We note that if the process $\{X_t : t \geq 1\}$ (assigning productivity rank to plants) is strictly stationary then the joint distribution of $(X_{t+\tau}, X_t)$ is independent of t and depends only on τ. Thus, under strict stationarity we could write

$$A_{t+\tau} = A_\tau.$$

The transition process would be Markovian if $A_\tau = A_1^\tau$.

It is really not possible to test the homogeneity property since, in view of the special character of the sets D_{tj}, for all t and all j, we have $\mathcal{P}(D_{tj}) = .1$. The relation in Eq. (14) is easily verified, directly, by the operation

$$\sum_{j=1}^{10} \mathcal{P}(D_{t+\tau,i} \mid D_{tj}) x_{tj} = \sum_{j=1}^{10} \mathcal{P}(D_{t+\tau,i} \cap D_{tj}) = \mathcal{P}(D_{t+\tau,i}) = x_{t+\tau,i},$$

due to the fact that $\mathcal{D}_t$ is a partition of the space. To show that the homogeneity condition cannot be tested, we note that because of the special nature of x_t, even if we replace

$A_{t+\tau}$ by $A_{t'+\tau}$ the condition

$$x_{t+\tau} \;=\; A_{t'+\tau} x_t$$

will continue to hold since

$$\sum_{j=1}^{10} \mathcal{P}(D_{t'+\tau,j} \mid D_{t'}) = 1;$$

thus, for every j, $x_{t+\tau,j} = .1$, even though we may assume that for $t \neq t'$,

$$\mathcal{P}(D_{t+\tau,j} \mid D_t) \neq \mathcal{P}(D_{t'+\tau,j} \mid D_{t'}).$$

Since we cannot disprove time homogeneity, we shall always **assume**, in subsequent discussion, that the matrix $A_{t+\tau}$ is **time homogeneous**, so that we shall write it as A_τ and we shall term it the τ-period **transition matrix**. An additional reason for this assumption is that there are not enough observations to enable us to estimate reliablv the elements of $A_{t+\tau}$, for all t. The time homogeneity assumption will allow us to estimate the elements of A_τ with ample degrees of freedom.

In Tables 1 through 16, in the Appendix, we give **one period** transition matrices; the construction of these tables is based on the following: Given the estimates of production functions, or Solow-like constructions, we obtain for each year a TFP assignment to each plant, having already taken into account time and (four digit) industry effects. We then order plants by the magnitude of their TFP and consider the incidence of transition, of plant i from decile d_t, in year t, to decile d_{t+1} in year $t+1$ or, possibly, exit from the industry in question. Now, exit may occur for a number of reasons; (a) the plant is eliminated (closed or scrapped); (b) the product mix of the plant has changed so that it is reclassified into another industry and (c) the plant is "downsized", so that it is no longer a "large" plant and hence it is out of the sample.[3]

If one ignores plant exit, which in the aggregate amounts to about 5% over the fifteen year period, one may then estimate the one-period transition matrices of the previous discussion, the two-period transition matrices and generally the τ-period transition matrices, obeying

$$x_{t+\tau} \;=\; A_\tau x_t, \tag{15}$$

[3] Actually, by the mechanics of Census sampling, as indicated in footnote 2, this can only occur at the end of a specified five year period.

where x_t is a ten-element column vector representing the probability of occupying the ten decile positions are time t, i.e., it contains the proportion of plants in the ten decile classifications of TFP, at time t. Note that the (i,j) element of A_τ is the proportion of plants making the transition from decile i to decile j over τ periods. Note, further, that by the very nature of the construction, $x_t = .1e$, where e is a ten-element column vector, all of whose elements are unity! The system in Eq. (15) becomes a relatively simple Markovian scheme if we have that $A_\tau = A_1^\tau$, where the matrix A_1 is the one period transition matrix, and is estimated from the experience of the plants over the entire fifteen year period. Similarly, we could construct two year transition matrices, three year transition matrices etc. To test whether the system is truly Markovian we test the hypothesis that

$$A_\tau = A_1^\tau. \tag{16}$$

If the Markovian hypothesis were accepted, one would write

$$x_{t+1} = Ax_t, \text{ or } x_t = A^t x_0, \tag{17}$$

and the interesting issues would revolve about the differences and/or similarities of transitional probabilities among the four digit industries, or higher levels of aggregation. We note that, because of the fact that transitional matrices are generally positive (i.e., all their elements are positive) and their columns sum to unity, they have the property that their largest characteristic root is unity and it is a simple root.[4] Thus, a long run equilibrium is defined in the sense that there exists a vector, say x^*, such that $x^* = A^\infty x_0$. The matrix A^∞ would then carry the totality of information regarding the equilibrium transition pattern. This exercise, however, would not be particularly useful in this context because of the special nature of the vector x_t, in the sense that $x_t = .1e$, for all t, where e is a vector of unities, and the condition above is automatically satisfied.

To test the Markovian property hypothesis we have used the particular cases $\tau = 5,4,3,2$. The juxtaposition of the matrices A_j and A_1^j (for the pooled sample containing all three industries) is given in Tables 17 through 20, in the Appendix. A simple inspection makes it quite evident that the Markovian property hypothesis is rejected.

[4] See Bellman (1960), pp. 256ff.

Interestingly, for both CD-derived and corrected Solow residual derived TFP, the main diagonal elements of A_5 tend to be noticeably larger than the corresponding elements of A_1^5, so that the evidence against a simple Markovian scheme is unambiguous. For that reason, and for the sake of simplicity, no formal testing has been carried out. Moreover, the Solow-residual-derived TFP yields generally higher diagonal elements, relative to CD-derived TFP, again confirming the "smoothness" features of this measure of TFP. We shall further comment on this point more fully below.

Since the Markovian view of the process is rejected, one must look for more complex explanations of the evolution of plant TFP. This would be the subject of another paper.

There is, however, one important issue that may be resolved a [illegible] level of analysis. Since TFP may be calculated in many ways, the question arises as to whether the conclusions that one derives from its analysis are invariant relative to the manner in which TFP is derived. A perusal of the tables (Tables 17 through 20 in the Appendix) gives indications of certain differences, but a definite pattern is not discernible; for this reason we have created the graphs in Figures 3 and 4, which depict the sums of the diagonals of the (normalized) transition matrices given in the appendix. In Figure 3, each graph depicts the behavior of industry 35, 36, 38 and the combined sample TFP, by type of derivation; in Figure 4, each graph depicts TFP as obtained from CD, TL (translog), Solow and Corrected Solow residuals. Thus, the entire Figure 4 represents the behavior of the three two digit industries and the combined sample, by type of TFP derivation, while the entire Figure 3 depicts the behavior of TFP, as derived from CD, TL, Solow and Corrected Solow residuals, in the context of the three two digit industries and the combined sample. Thus, the ordinate of a graph at zero, for example, indicates the "probability" of remaining in the same decile. The ordinate at -1 indicates the probability of moving down one decile (over a single period), the ordinate at -2, of moving down two deciles; similarly, the ordinate at 1 indicates the probability of moving up one decile, over a single period, and so on. When presented in this fashion a clear pattern emerges from Figure 3, viz., for all industries, the simple Solow residual measure of TFP gives the highest probability of remaining in the same decile classification of TFP, followed by the corrected Solow residual (i.e., the residual from which time and four digit industry effects are removed). The CD- and translog-based measures of TFP yield results that are almost indistinguishable from each other, but the probabilities of "stayers" are appreciably smaller than those implied by the two versions of the Solow residuals. This is another instance of a phenomenon noted

Fig. 3

Transition Density, by Residual Type

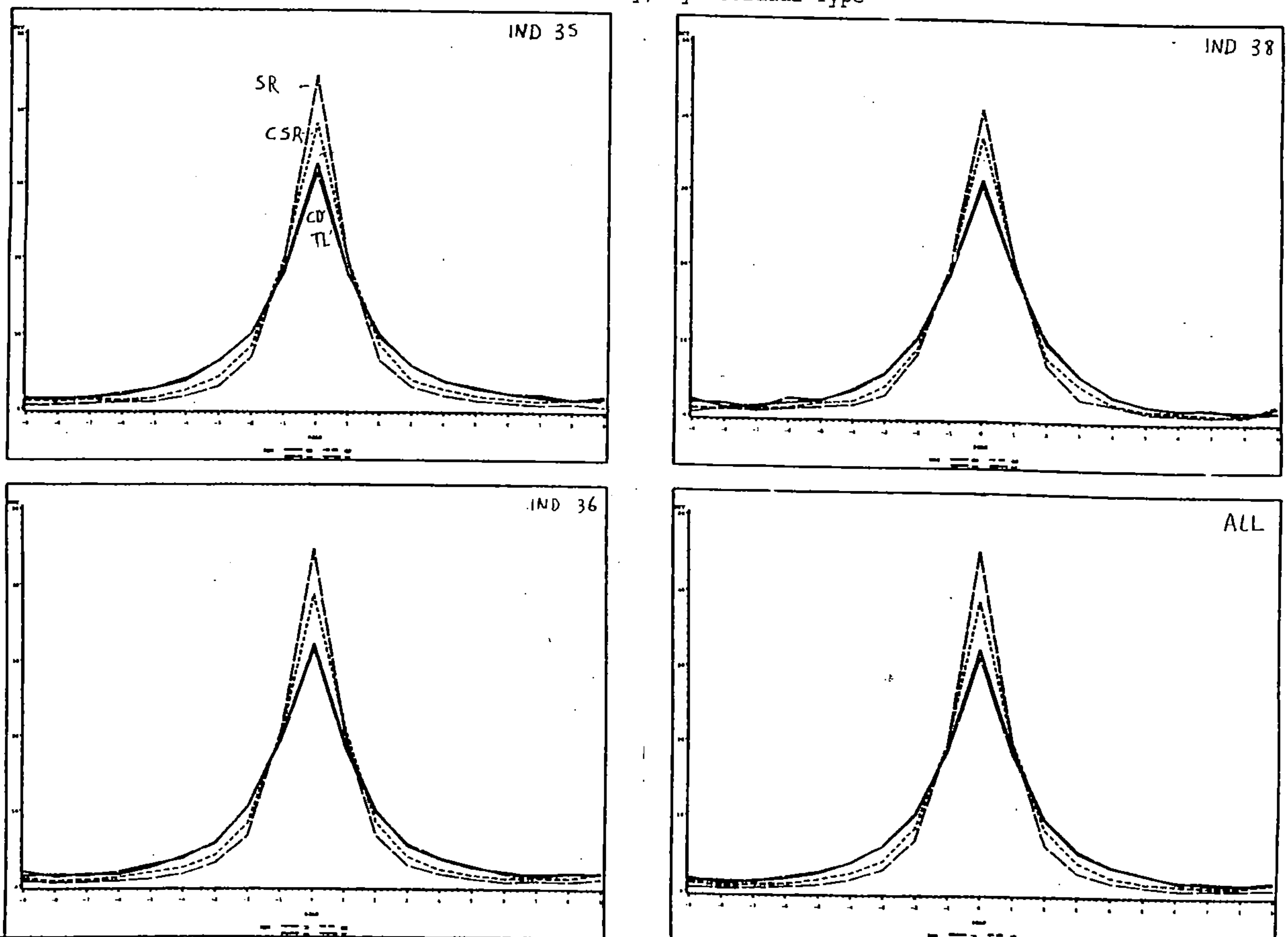


Fig. 4

Transition Density, by Industry

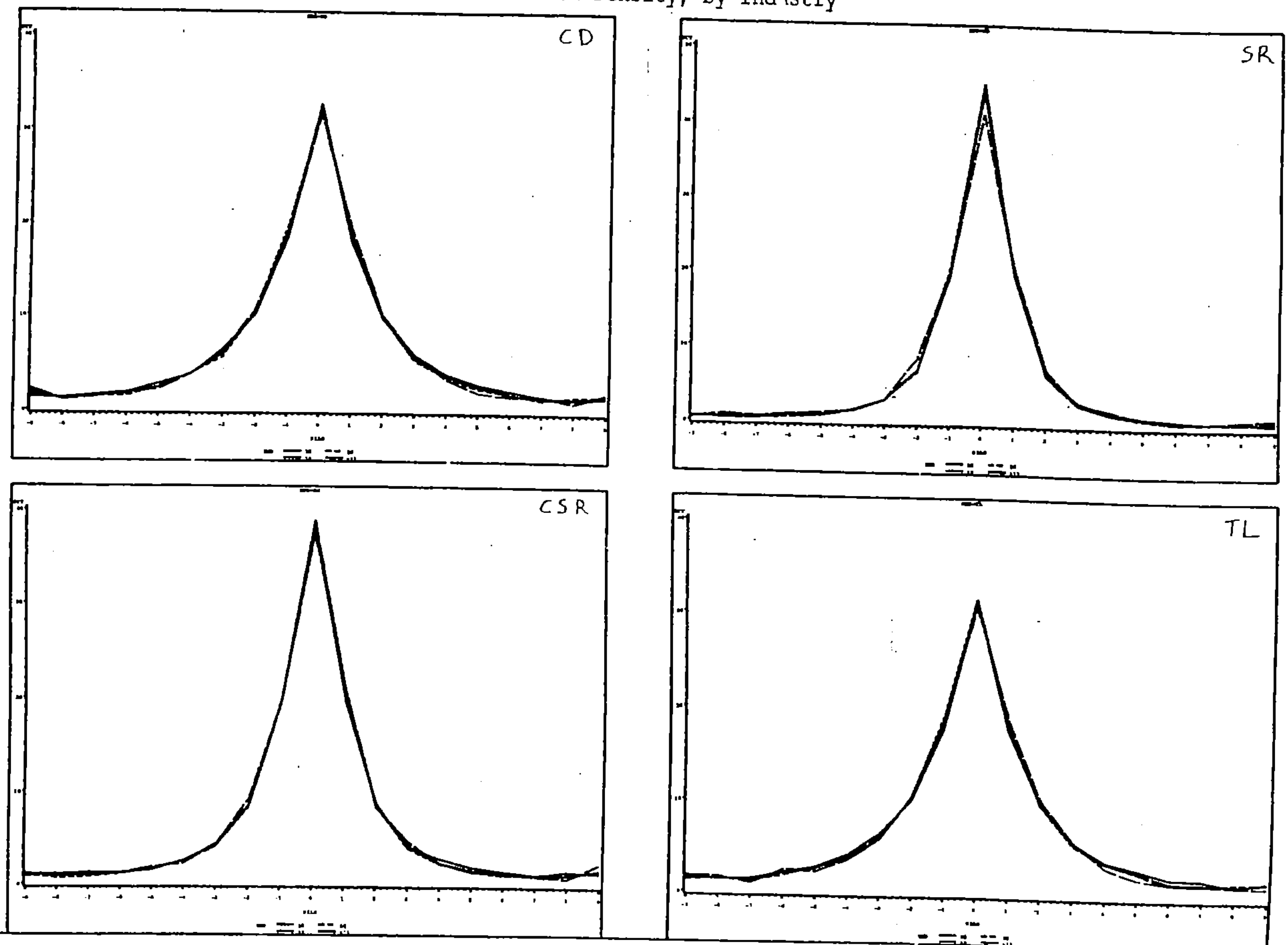
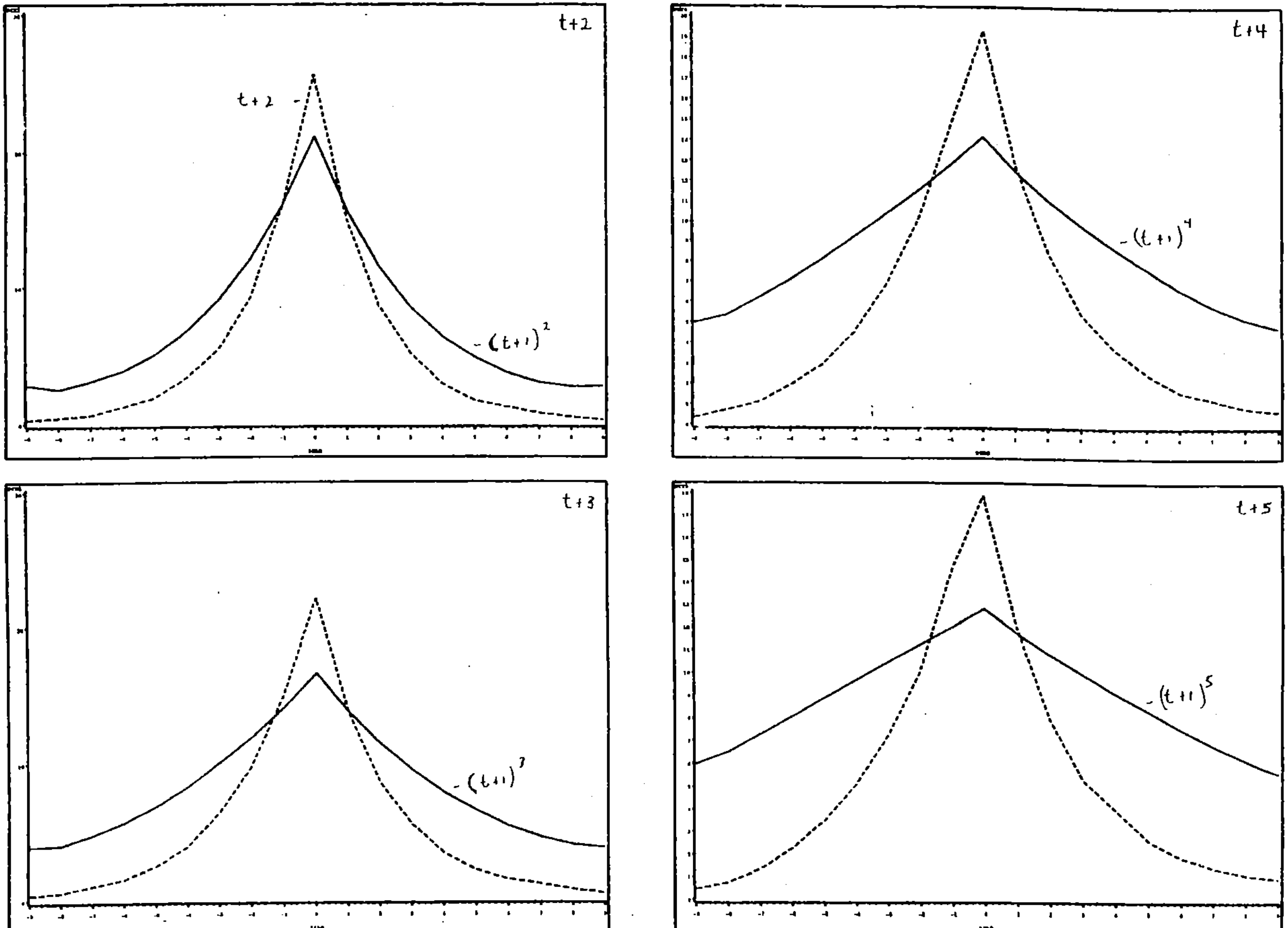


Fig. 5

Transition Density, Type = CD and Ind. = All



earlier, viz., the greater smoothness of the Solow residual, Dhrymes (1991), and which may be attributed to the great number of parameters being used in the process of deriving it.

From Figure 4 we see that, if we fix the method of measuring TFP then the three two digit industry and their combined sample give essentially the same results.

Finally, in Figure 5, we give some graphic evidence regarding the Markov character of the transition process, based on CD-residuals; in each of the graphs of Figure 5, the solid line-graph represents the plot of the diagonal sums of A_1^j, $j = 2, 3, 4, 5$, proceeding clockwise from the upper left corner. In Figure 6, we depict the same situation relative to CSR based measures of TFP. In both cases the qualitative results are almost identical and imply a substantial departure of A_1^j from A_j; what is clear, uniformly, is that the (sum of the) main diagonal elements of A_1^j **substantially underestimates** (the sum of) the main diagonal elements of A_j, while **the sum of the sub- and super-diagonals is, correspondingly, overestimated**.

Given the qualitative differences between the Solow residual and CD- or TL-based measures of TFP established in this section, it would appear that a number of past studies, that rely heavily on Solow-residual-like measures of TFP, may exaggerate the smoothness of the process and perhaps the rate of its growth.

4 TFP Rankings by Four Digit Industry

Having allowed for the possibility that the production relations may differ systematically by year (time effects), due to the macro environment faced by plants (or, possibly, neutral technical change), and four digit industry (industry effects) due to possible differences in the technology of producing different kinds of products, we may still enquire as to whether plants in four digit industries have substantially similar TFP rankings. This is answered in Tables 21, 22 and 23, in the Appendix. Given the findings of the preceding section, we are making a comparison only between the CSR- and CD-based measures of TFP. If plants' TFP followed a **uniform distribution in every four digit industry** then all entries in, say, Table 21 would be 30, 40, 30 respectively, under the headings $Lo30$, Mid and $Hi30$. In all three tables, however, the situation is quite different and the empirical distribution departs appreciably from the uniform regime. This is, of course, not totally unexpected since the (logarithm of the) residuals, which constitute the measure of TFP, sum to zero, in the CD case and in both CD and corrected Solow residual derived TFP the (logarithms of the) residuals are orthogonal to the "time" and "industry" dummies. Thus, if some plants have unusually large TFP, others must have "unusually" low. Of greater importance, perhaps, is that there are systematic differences in the distribution of CD- and corrected Solow-residual-based TFP. We summarize this in Table 1, below, [5] which records the minimum, maximum and average fraction of plants in four digit industries that fall in the *Lo*30, *Mid* and *Hi*30 classifications on a two digit industry wide basis. As is obvious from the table, while on the average the fractions are close to the theoretical limits for both measures of TFP, the ranges vary quite appreciably as between the CD-derived and the corrected Solow residual based measures of TFP.

TABLE 1

Range of Rankings, Industries 35, 36, 38

	CSR/TFP			CD/TFP		
SIC	Lo30	Mid.	Hi30	Lo30	Mid.	Hi30
IND. 35						
Minimum	18.5	33.2	15.9	19.8	9.8	19.4
Maximum	41.1	64.9	46.3	41.1	59.3	37.7
Average	29.2	42.0	28.8	29.5	42.1	28.4
IND. 36						
Minimum	19.3	21.1	17.1	19.8	0.0	17.8
Maximum	44.6	61.0	39.0	66.7	59.9	43.2
Average	29.9	42.2	29.6	30.2	40.7	29.2
IND. 38						
Minimum	23.0	24.7	17.6	23.1	31.8	24.1
Maximum	32.7	59.4	44.1	33.9	49.3	35.9
Average	29.9	40.1	30.1	29.6	41.3	29.1

5 Age and Productivity

It is a widely held view that new plants are the bearers of new technology and "hence" more productive than old plants. Whereas there is no doubt that the statement is true if "old"

[5] All tables in the text are based on the pooled sample, containing the observations on industries 35, 36, and 38, over the period 1972-1986.

TABLE 2						
Productivity Transitions by Age of Plant						
Age	**Prod.**	**nobs.**	**Lose**	**Stay**	**Gain**	**Exit**
CD/TFP						
1–2	5.65	1,036	20.8	57.7	21.4	0.0
3–4	5.79	1,254	18.7	60.5	20.7	0.0
5–6	5.77	1,688	15.7	64.3	17.8	2.3
7–10	5.60	4,034	16.9	63.0	17.4	2.7
11–14	5.53	4,491	17.3	62.2	18.3	2.1
15–20	5.51	6,273	16.3	65.4	16.0	2.3
21–26	5.61	6,806	16.9	65.4	16.3	1.5
> **26**	5.36	20,050	17.5	65.8	14.4	2.4
CSR/TFP						
1–2	5.46	1,055	19.8	61.5	18.7	0.0
3–4	4.98	1,261	16.2	66.0	17.8	0.0
5–6	4.95	1,695	13.9	67.2	16.6	2.2
7–10	4.93	4,052	13.9	68.3	15.1	2.6
11–14	5.10	4,499	12.2	70.6	15.2	2.1
15–20	5.35	6,292	12.1	73.0	12.7	2.3
21–26	5.70	6,823	12.0	75.1	11.4	1.5
> **26**	5.77	20,068	12.3	74.6	10.8	2.4

refers to plants of age 100, it is not clear that there is strong empirical evidence for this proposition if "new" and "old" refer to plants of age 1-3, for example, vis-a-vis plants of age 8-10. In an attempt to address this issue, we consider two types of evidence. First, in Appendix Tables 1 through 16, we see the percentage of births entering in each productivity decile. Entrants do not seem to uniformly come in at either high or low productivity levels [6]. Next, we provide, in Table 2, below, , a tabulation of the productivity transitions of plants, classified by age. The heading CD/TFP indicates that TFP is determined from the residuals of the CD function, taking into account "time" and (four digit) industry effects; the heading CSR/TFP indicates that TFP was determined by the corrected Solow residual, i.e., after "time" and (four digit) industry effects have been removed (by regression). First, we note that the categories Lose (which indicates downward plant transition by more than one decile) and Gain (which

[6] In industry 35, which includes computers, a large proportion of births take place into the highest decile; when the four digit industry 3573 (computers) is excluded, this phenomenon disappears.

indicates upward plant transition by more than one decile) tend to decline with age. The Stay category (which indicates plant transition by at most one deciles shows increase with age. The apparent decline in the Gain category for relatively old plants (over 21 years in age) could possibly be attributable to such plants occupying a higher decile position; for example, if a plant is in the ninth decile, by the construction of this table, such plant cannot gain, it can only stay or lose. That this is not the case is corroborated by the fact that the average productivity decile of the plants in each age group does not discernibly increase with age (the "Prod." column shows average rank of plants, with 1 being the lowest and 10 the highest level of ranking). What appears to be the case, is that there is a great deal of uncertainty about the fate of a plant upon entry, which is reflected in the somewhat larger lose and gain category for plants one to two years old; as age grows the survivors tend to stabilize in their ranking, so that there appears to be something akin to "learning by doing".

Second, a striking feature of the table is that CD-derived TFP yields a lower fraction of stayers than the corrected Solow residual derived TFP–and rather by an appreciable margin; it also yields a higher fraction of losers and gainers.

Thus, the findings in this phase of our investigation tend to offer further corroborating evidence that the corrected Solow residual based TFP is appreciably smoother relative to the CD derived measure.

More detailed results are given in Tables 24 through 31, in the Appendix. These tables tabulate the same information as Table 2, above, except that the information is given by age groups (less than 5, between 5 and 15, over 15) for the three two digit industry separately and for the pooled sample, covering all three. Although details differ, the basic, broad, qualitative results remain the same in the aggregate, although some variations are observed for individual industries.

6 Size and Productivity

The relationship between size and productivity is not entirely clear in the literature. To the extent that there is a consensus, it seems to center on the view that productivity increases with size up to a point and then begins to decline. In Table 3, below, we give a tabulation of average productivity ranking and of the productivity transition experience of plants, classified by average employment (over the years 1972-1986). The disparate numbers of observation are due to the fact that even if we divide the number of plants into ten equal groups,

TABLE 3

Transition Probabilities by Average Size of Employment

Decile	Prod.	nobs	Enter	Lose	Stay	Gain	Exit
CD/TFP							
1	5.62	3,755	2.7	19.2	59.7	16.8	4.4
2	5.64	3,987	2.7	19.5	60.7	16.7	3.1
3	5.62	4,217	1.5	17.1	64.5	15.7	2.7
4	5.55	4,457	1.2	17.4	64.2	16.1	2.2
5	5.48	4,463	1.4	17.5	64.9	15.6	2.0
6	5.40	4,645	1.2	17.7	64.1	16.4	1.9
7	5.37	4,808	1.1	17.0	65.9	15.7	1.4
8	5.55	4,871	0.8	16.7	66.5	15.6	1.2
9	5.45	5,140	0.4	16.1	67.0	15.8	1.1
10	5.40	5,130	0.3	14.7	68.9	15.3	1.1
CSR/TFP							
1	4.94	3,788	2.6	14.8	66.4	14.5	4.3
2	5.08	4,002	2.7	14.4	69.2	13.4	3.1
3	5.41	4,221	1.5	12.8	72.5	11.9	2.7
4	5.45	4,463	1.2	13.5	70.8	13.5	2.2
5	5.48	4,474	1.4	12.6	73.5	12.0	1.9
6	5.35	4,659	1.2	12.5	73.3	12.3	1.9
7	5.53	4,820	1.1	13.3	72.8	12.4	1.4
8	5.66	4,875	0.8	11.4	75.3	12.1	1.2
9	5.82	5,145	0.4	11.5	75.6	11.8	1.1
10	6.02	5,139	0.3	10.5	77.0	11.4	1.1

the number of plant years may not be same in each group; hence the discrepancies. Certain important results emerge from the table; first, the probability of staying increases with size, and this is so whether one looks at CD-based on CSR-based measures of TFP; we we had also noted earlier, the CSR-based measure gives a higher probability of staying than the CD-based measure. Second, entry and exit are considerably more likely at the first three deciles than they are at the last three deciles, and this is true for both CD- and CSR-based measures of TFP. Third, the probability of being in the Lose and Gain category is higher for CD-based than it is for CSR-based measures of TFP.

An interesting observation is that the **productivity rank** tends to **increase with size** for the **CSR/TFP** measure, while it is unchanged for the **CD/TFP** measure. Further, it is seen that large plants are less likely to exit or to move down the productivity rankings than are smaller plants.

7 Conclusion

In this paper we have examined the behavior of TFP, under a variety of circumstances, for industries 35 (Machinery, Except Electrical), industry 36 (Electrical and Electronic Equipment and Supplies) and industry 38 (Measuring Instruments...), over the period 1972-1986. These industries are thought to represent the technologically most advanced sector of US manufacturing. While a number of measures have been employed, the two measures examined most extensively are those based on Cobb-Douglas, and corrected Solow residuals. In both cases we have removed from our measures the influence of the macro environment, and the diversity of product, via time and four digit industry dummies. What remains, thus, is the "production shocks" represented by the structural error in the production function formulation context, as well as other latent forces that contribute to the augmentation of output beyond the specified inputs and other predictable, or at least controllable factors. We have deliberately refrained from using complex econometric procedures since, at this stage, we do not have a complete model formulation of the phenomenon under study.

The salient findings of this study are:

i. There are serious aggregation problems in dealing with aggregate measures of productivity. Thus, if we consider the mean of **individual plant productivity**, the time profile of this entity is one that exhibits nearly constant decline from 1974 through 1982 or 1984 and, thereafter, substantial recovery. If we look at aggregate productivity, obtained by adding up the contributions to output of the specified inputs, and compute TFP from similarly summed outputs, the time profile of this entity is one that first exhibits a slight dip in the early seventies and thereafter considerable growth. This argues against the view of the economy in terms of the "representative" plant or firm and indicates that a part of an economy's productivity growth accrues by means of resource reallocation from "less" to "more" productive plants. Thus, aggregate studies of productivity are seriously deficient, convey too simplistic a view of the process, and may very well be quite misleading.

ii. While there are substantial similarities in TFP behavior, irrespective of how it is computed, [7] there are also appreciable and persistent differences between Solow-residual- and corrected-Solow residual-derived measures on one hand, and Cobb-Douglas- or translog-derived measures on the other. The last two yield almost identical results.

iii. Underlying the placidity of aggregate production at the two digit industry level, there is a vigorous dynamic process that constantly redefines the position of plants in the industry wide ordering of productivity. How much of this is a genuine phenomenon and how much is due to errors in variables problems [8] is still an open question. The productivity transition process is not a simple Markovian process, and the underlying reasons for the transitions are not well understood; clearly, more research is indicated along these lines.

iii. New plants are not uniformly more productive than "old" plants, but what appears to be the case is that new plants face greater uncertainty in their evolution, exhibiting greater probability of both improving and worsening their productivity standing. It is also not true that new plants enter at the high end of the productivity scale. What is true is that older plants exhibit more stability, in the sense that the probability of staying in a band of one decile on either side of the current position increases with age. Thus,

[7] In this study this means Solow and corrected Solow residuals, as well as Cobb-Douglas and translog derived TFP measures.

[8] In general, the use of such sterile econometric phrases should be avoided, but we bow to general practice. What is at issue here is whether or not what we call productivity gains or losses, in this study or in any other study, does in part, at least, reflect greater or lesser utilisation of factors (resources) owned or employed by the plant. For example, if there is a precipitous drop in demand, output will adjust faster than inputs, thereby resulting in "productivity losses"; conversely, if following a period of slack demand there is sudden substantial increase, output will adjust faster than inputs, since typically there is input hoarding; the result is "productivity gains". This, however, is not what we have in mind when we examine productivity issues.

some process of "learning by doing" may characterize the evolution of the productivity aspect of new plants. Again, these are intriguing findings that require further study.

iv. Larger plants (in terms of labor employment) appear to be more productive than smaller plants. This means that larger plants are less likely to exit, less likely to move down the productivity rankings and more likely to maintain their rankings. Smaller plants, on the other hand are more likely to exit and more likely to move up or down the productivity rankings. Thus, the impression that emerges is one in which new plants being generally smaller, tend to improve or deteriorate initially, as we noted in iii. above; as they grow, however, they are more likely to retain their productivity ranking. Although the interaction between size and age is not given explicitly, it would appear from Tables 2 and 3, that as plants survive they become large and more likely to occupy and retain a higher productivity rank.

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Table A.1: Transition T= t to T= $t+1$,ind= i35, type= CD

	1	2	3	4	5	6	7	8	9	10	Ex.
1	55.4	16.6	7.7	4.9	3.5	2.8	2.1	1.4	1.5	1.4	2.7
2	18.0	31.7	21.0	9.5	7.0	4.6	2.5	2.1	1.7	0.9	1.0
3	7.7	20.1	24.3	18.2	11.0	7.1	4.0	2.9	2.3	1.4	1.1
4	5.2	11.2	17.1	21.9	16.9	11.4	6.3	4.5	3.2	1.7	0.7
5	2.8	7.6	10.6	18.0	20.2	16.7	11.4	6.5	3.6	2.0	0.7
6	2.3	4.6	8.0	11.4	17.5	20.9	16.8	11.3	4.4	1.9	0.9
7	2.0	3.2	4.6	6.8	11.4	17.2	23.5	18.3	8.2	4.0	0.9
8	2.0	2.4	3.6	4.5	7.6	10.6	17.4	27.2	18.7	5.5	0.6
9	1.5	1.6	1.7	2.9	3.2	6.2	10.5	18.2	36.7	16.9	0.7
10	1.3	1.0	1.0	1.1	1.4	2.2	3.4	6.6	19.4	61.6	0.9
Ent	19.1	6.4	5.0	7.1	9.2	5.7	7.1	4.3	7.1	29.1	0.0

Table A.2: Transition T= t to T= $t+1$,ind= i35, type= TL

	1	2	3	4	5	6	7	8	9	10	Ex.
1	54.3	17.7	7.0	4.7	3.7	3.2	1.8	1.9	1.3	1.8	2.7
2	17.1	30.5	20.7	10.7	6.9	4.4	3.1	2.2	2.2	1.2	0.9
3	8.3	19.8	24.4	16.8	12.0	6.7	4.5	2.4	2.3	1.8	1.1
4	4.5	10.3	17.9	22.4	17.1	11.1	6.7	4.1	3.3	1.8	0.7
5	3.9	7.1	10.5	17.3	19.6	16.6	11.2	6.6	3.6	2.7	0.9
6	2.2	5.1	8.2	12.6	15.7	20.6	17.1	10.5	5.4	1.9	0.5
7	2.4	3.7	5.1	7.3	11.0	18.2	21.4	17.3	9.7	3.2	0.7
8	1.8	2.6	2.7	4.6	7.1	9.8	16.7	28.0	19.2	6.7	0.7
9	1.8	1.4	2.5	2.6	3.8	6.1	11.3	19.5	33.5	16.7	0.8
10	1.4	0.9	1.1	1.1	2.4	2.4	4.4	6.8	18.6	59.8	1.0
Ent	17.0	10.6	2.1	7.1	5.7	9.2	6.4	3.5	9.2	29.1	0.0

Table A.3: Transition T= t to T= $t+1$,ind= i35, type= SR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	62.6	20.2	7.5	2.9	1.7	0.9	0.8	0.5	0.6	0.3	1.8
2	19.9	40.8	21.2	7.4	3.4	1.9	1.6	1.1	0.6	0.8	1.2
3	6.7	21.9	33.2	21.3	7.3	3.5	2.4	1.3	0.9	0.5	0.9
4	3.3	7.2	20.1	32.8	20.6	8.0	3.9	1.9	1.2	0.4	0.7
5	1.5	3.5	8.8	20.0	31.5	20.8	7.3	3.2	2.0	0.6	0.8
6	1.3	2.0	3.6	7.6	20.9	32.8	21.1	6.3	2.7	0.8	0.9
7	1.0	1.1	2.5	3.7	8.2	20.6	35.3	20.3	5.5	1.2	0.7
8	0.7	0.8	1.0	2.0	3.1	8.0	20.5	42.6	18.1	2.3	0.8
9	0.5	0.8	1.2	0.6	1.5	2.5	5.6	19.4	54.8	11.9	1.1
10	0.4	0.5	0.4	0.4	0.5	0.6	1.2	2.9	12.6	79.2	1.2
Ent	9.0	9.7	5.5	6.9	4.8	6.9	4.8	7.6	10.3	34.5	0.0

Table A.4: Transition T= t to T= $t+1$,ind= i35, type= CSR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	59.4	19.0	7.5	3.6	2.4	1.4	1.2	1.2	1.0	1.2	2.2
2	18.4	40.4	20.4	8.1	3.7	2.5	1.6	1.2	0.6	1.7	1.1
3	7.5	20.7	30.0	20.1	9.5	4.2	2.8	1.9	1.5	1.1	0.7
4	3.8	8.3	19.4	27.8	19.2	10.0	4.6	2.8	1.9	1.4	0.7
5	2.3	4.0	9.8	20.0	25.5	18.9	9.8	4.3	2.9	1.5	0.9
6	1.2	2.6	4.4	8.7	20.2	28.7	19.3	8.8	3.5	2.4	0.3
7	1.1	1.4	3.0	4.6	10.1	19.0	27.8	21.2	8.1	2.9	0.8
8	1.4	0.6	1.6	2.9	5.3	8.9	20.6	32.2	19.4	6.2	0.9
9	1.0	0.9	1.0	1.8	2.1	4.6	8.0	20.3	42.3	16.9	1.1
10	1.1	1.0	1.3	1.7	1.2	1.9	2.7	5.6	18.8	63.4	1.4
Ent	13.8	12.4	13.1	6.2	4.8	5.5	10.3	6.2	9.7	17.9	0.0

Table A.5: Transition T= t to T= $t+1$,ind= i36, type= CD

	1	2	3	4	5	6	7	8	9	10	Ex.
1	51.7	19.8	8.6	4.6	3.6	2.1	2.2	1.0	1.6	1.6	3.1
2	19.3	31.0	20.7	10.9	5.9	3.8	2.4	1.9	1.4	1.4	1.3
3	9.9	20.2	24.0	18.0	12.0	5.4	4.1	3.0	1.5	1.1	1.0
4	4.5	10.8	20.0	22.1	17.5	11.1	6.5	4.0	1.8	1.3	0.6
5	3.8	6.2	10.5	18.0	20.7	18.3	10.7	5.7	3.6	1.9	0.6
6	3.1	4.6	6.2	12.3	18.2	21.7	17.0	10.3	4.5	1.6	0.6
7	1.4	2.5	5.1	7.0	11.1	19.1	24.0	17.7	8.3	3.2	0.4
8	1.5	1.7	2.9	3.5	6.1	11.5	18.9	27.0	19.6	6.6	0.8
9	1.2	1.4	1.0	2.0	3.7	4.5	9.6	21.2	36.9	17.8	0.6
10	1.8	1.1	1.5	1.5	1.3	2.1	4.1	7.7	19.7	58.1	1.1
Ent	7.7	12.1	9.3	11.0	8.2	6.0	7.7	7.7	11.5	18.7	0.0

Table A.6: Transition T= t to T= $t+1$,ind= 36, type= TL

	1	2	3	4	5	6	7	8	9	10	Ex.
1	51.4	19.5	8.9	4.8	3.7	2.0	1.6	1.4	1.8	1.6	3.3
2	20.1	29.1	21.0	11.0	6.1	3.7	2.9	1.8	1.5	1.4	1.5
3	8.9	19.4	25.0	17.2	11.5	6.2	4.6	3.6	1.3	1.4	0.9
4	5.1	12.7	18.7	21.9	16.6	10.7	5.6	4.5	2.4	1.2	0.7
5	3.2	6.6	10.6	17.5	21.9	18.3	10.5	6.0	2.9	1.8	0.7
6	3.1	4.2	5.8	11.7	18.7	22.1	16.7	9.8	5.4	2.3	0.2
7	1.9	3.8	4.2	6.9	11.0	18.1	24.1	17.5	8.2	4.0	0.3
8	1.5	2.1	3.0	4.8	5.8	10.9	18.8	27.4	18.0	6.8	0.8
9	1.5	1.0	1.7	2.2	2.9	5.4	10.2	20.0	36.4	18.4	0.5
10	1.3	1.4	1.2	1.5	1.8	2.2	4.6	7.1	20.9	56.8	1.3
Ent	8.8	8.2	8.8	11.5	6.6	9.3	8.2	8.8	9.3	20.3	0.0

Table A.7: Transition T= t to T= $t+1$,ind= i36, type= SR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	61.8	20.1	6.3	2.9	1.7	1.6	0.7	0.7	0.4	0.9	2.7
2	19.3	42.4	22.4	7.8	3.3	1.7	0.9	0.4	0.5	0.5	0.8
3	6.3	21.5	35.7	21.2	8.1	3.4	1.4	0.9	0.3	0.4	0.9
4	4.1	7.1	20.7	34.9	20.4	7.3	2.9	1.3	0.3	0.2	0.7
5	2.0	4.1	8.1	19.7	33.5	20.1	7.4	2.7	1.2	0.5	0.8
6	1.2	2.1	3.3	7.4	21.8	33.9	19.3	6.9	1.9	1.5	0.8
7	0.9	1.0	1.8	2.9	6.9	21.6	37.5	19.1	5.8	1.8	0.8
8	0.6	0.7	0.9	1.1	2.8	6.9	22.5	42.6	17.8	3.5	0.6
9	0.5	0.3	0.4	0.7	0.8	2.0	5.2	20.2	52.0	17.0	0.9
10	0.5	0.2	0.4	0.3	0.4	1.1	1.8	4.7	18.1	71.5	0.9
Ent	13.5	7.8	10.4	6.8	4.7	10.9	7.8	9.4	14.1	14.6	0.0

Table A.8: Transition T= t to T= $t+1$,ind= i36, type= CSR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	59.2	19.6	6.9	3.1	2.4	1.3	0.9	1.4	0.9	1.5	2.8
2	18.2	40.1	23.3	7.7	3.9	2.1	1.3	1.1	0.6	1.0	0.9
3	8.6	19.6	30.3	21.2	9.8	4.4	2.2	1.2	0.9	0.9	0.9
4	3.4	8.4	19.0	30.6	19.9	10.1	4.1	1.9	1.2	0.7	0.7
5	1.8	4.5	9.3	18.7	26.3	20.5	9.1	5.0	2.4	1.6	0.7
6	1.6	3.3	4.2	8.4	19.9	27.9	20.7	8.7	2.9	1.5	0.9
7	1.1	1.8	2.8	4.6	9.6	20.4	28.7	20.2	7.2	2.7	0.7
8	0.8	1.0	1.5	2.1	4.6	6.8	21.5	32.8	21.6	6.6	0.7
9	0.4	0.4	0.9	1.9	2.1	3.9	8.8	21.1	41.9	17.7	0.8
10	0.9	0.8	0.9	1.0	1.4	2.1	2.3	5.9	20.2	63.7	0.9
Ent	19.3	13.5	9.9	4.7	7.3	6.2	7.8	11.5	7.8	12.0	0.0

Table A.11: Transition T= t to T= $t+1$,ind= 38, type= SR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	64.3	20.6	6.1	2.3	1.0	0.2	0.6	0.2	0.8	1.1	2.9
2	20.4	43.4	20.6	7.1	2.4	1.3	1.3	0.4	0.4	1.1	1.7
3	6.5	18.6	33.4	22.3	8.7	3.1	2.4	0.9	1.1	1.1	1.8
4	1.9	7.6	22.7	32.0	18.8	7.4	3.0	3.2	1.5	1.1	0.8
5	0.6	3.9	9.7	20.2	32.2	19.9	6.8	3.1	2.2	0.9	0.6
6	1.1	1.5	2.6	8.0	19.8	32.7	20.4	8.4	3.2	1.9	0.4
7	0.2	0.6	2.0	3.0	8.6	20.1	35.3	19.1	8.7	1.9	0.6
8	0.0	1.1	0.9	1.6	4.0	10.0	17.7	36.4	23.3	4.2	0.7
9	0.5	0.5	0.5	1.5	2.0	3.1	9.9	21.2	41.0	19.2	0.5
10	0.4	1.3	1.3	2.1	2.1	1.5	2.1	7.2	17.7	63.1	1.3
Ent	10.5	8.8	8.8	12.3	14.0	10.5	10.5	0.0	8.6	15.8	0.0

Table A.12: Transition T= t to T= $t+1$,ind= 38, type= CSR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	57.3	22.2	6.0	3.7	2.3	1.4	0.8	0.6	0.8	2.1	2.7
2	18.9	38.1	20.9	9.1	5.0	3.3	0.7	0.2	1.1	0.4	2.2
3	7.3	19.9	32.0	20.7	9.5	3.5	1.8	1.5	2.2	0.7	0.9
4	3.9	8.4	21.7	27.7	18.6	8.6	5.2	2.0	1.5	1.1	1.3
5	2.8	5.2	8.4	19.7	25.1	20.3	8.9	6.1	1.9	1.3	0.2
6	2.0	1.5	4.5	10.8	18.7	27.5	21.2	7.2	4.6	1.5	0.6
7	0.7	2.2	1.7	3.3	9.8	20.1	28.5	21.5	8.5	3.1	0.6
8	0.2	1.1	1.3	2.2	5.7	9.9	19.8	31.9	20.7	6.8	0.4
9	0.6	0.6	1.1	1.3	2.8	4.1	10.2	20.3	40.5	17.5	1.1
10	0.9	1.1	1.9	1.5	2.1	1.7	2.1	8.4	17.6	61.4	1.3
Ent	12.3	12.3	5.3	7.0	12.3	17.5	5.3	10.5	3.5	14.0	0.0

Table A.9: Transition T= t to T= $t+1$,ind= 38, type= CD

	1	2	3	4	5	6	7	8	9	10	Ex.
1	47.7	21.7	9.1	3.8	4.0	2.2	2.2	1.2	1.4	1.8	4.8
2	21.6	31.1	18.9	9.0	7.6	4.6	2.7	1.3	1.7	0.2	1.3
3	8.3	16.7	26.1	20.2	11.9	8.1	3.0	2.4	0.9	1.7	0.7
4	6.2	10.2	20.1	22.2	17.0	11.4	6.4	3.2	0.8	1.3	1.1
5	3.0	10.0	10.5	18.7	18.5	16.8	11.8	5.5	3.3	1.1	0.7
6	4.0	5.4	6.7	14.7	17.4	19.0	17.0	8.9	6.0	0.7	0.2
7	1.6	2.2	3.4	5.6	11.3	18.9	21.9	20.7	11.5	2.3	0.5
8	2.2	2.0	1.5	3.0	5.6	11.7	19.3	28.6	20.8	5.0	0.4
9	1.1	1.1	2.2	1.4	4.1	5.0	11.1	19.7	34.2	19.5	0.5
10	2.1	1.0	0.8	1.2	1.5	3.3	2.5	6.9	16.8	63.0	1.0
Ent	7.4	11.1	11.1	16.7	7.4	7.4	5.6	11.1	11.1	11.1	0.0

Table A.10: Transition T= t to T= $t+1$,ind= 38, type= TL

	1	2	3	4	5	6	7	8	9	10	Ex.
1	48.0	21.7	8.0	6.0	2.4	2.6	2.2	1.8	1.8	1.2	4.4
2	18.6	33.9	20.9	9.8	5.6	3.3	2.1	1.5	1.5	0.8	2.1
3	9.6	18.7	23.3	17.6	12.9	8.7	4.5	1.5	1.7	0.9	0.6
4	5.9	9.3	20.1	21.0	18.2	12.5	5.4	3.5	2.2	0.4	1.5
5	4.1	6.9	12.0	16.9	20.0	16.9	12.0	6.0	3.9	1.3	0.0
6	1.8	4.0	7.9	14.2	18.5	20.1	15.5	11.0	5.6	0.9	0.5
7	3.1	2.7	2.9	6.0	9.8	18.9	21.2	20.9	10.3	3.6	0.5
8	1.5	2.4	2.6	3.9	5.5	9.9	20.2	25.2	22.2	6.2	0.4
9	2.2	1.3	1.8	2.7	3.5	5.7	11.7	20.0	32.1	18.3	0.7
10	1.7	1.1	0.0	2.4	1.3	2.6	2.4	7.3	16.5	63.9	0.6
Ent	11.1	5.6	13.0	13.0	11.1	3.7	9.3	7.4	16.7	9.3	0.0

Table A.13: Transition T= t to T= $t+1$,ind= All, type= CD

	1	2	3	4	5	6	7	8	9	10	Ex.
1	53.0	18.7	8.0	5.0	3.6	2.3	1.9	1.2	1.5	1.5	3.3
2	19.2	31.2	20.6	10.5	5.8	4.5	2.5	1.8	1.5	1.0	1.3
3	8.6	20.3	24.7	19.1	10.9	6.0	3.9	2.8	1.7	1.2	0.9
4	5.2	11.4	18.1	21.7	18.4	10.7	6.3	3.6	2.7	1.3	0.7
5	3.4	6.8	11.3	17.8	20.1	17.6	10.7	6.2	3.6	1.9	0.6
6	2.5	4.5	6.5	11.5	18.2	22.2	17.0	10.8	4.3	1.8	0.6
7	1.9	2.5	5.0	6.6	11.1	17.9	24.1	17.7	9.1	3.5	0.6
8	1.9	2.1	2.9	4.3	6.6	10.4	18.4	27.2	19.8	5.9	0.6
9	1.2	1.2	1.8	2.2	3.4	5.7	9.9	20.8	35.5	17.6	0.7
10	1.6	1.0	1.2	1.1	1.5	2.3	4.1	6.6	19.2	60.6	0.9
Ent	11.7	9.3	8.5	10.1	8.2	7.2	6.6	6.9	10.3	21.2	0.0

Table A.14: Transition T= t to T= $t+1$,ind= All, type= TL

	1	2	3	4	5	6	7	8	9	10	Ex.
1	52.3	18.6	8.4	4.9	3.3	2.7	1.6	1.8	1.5	1.7	3.1
2	19.0	30.4	20.4	10.7	6.6	4.3	2.9	1.8	1.5	1.2	1.2
3	8.8	19.7	24.9	17.5	10.9	6.9	4.1	2.8	1.8	1.4	1.2
4	5.1	11.7	17.6	22.0	17.3	11.0	6.4	4.1	2.7	1.3	0.8
5	3.3	6.7	10.8	18.6	20.6	16.9	11.1	6.0	3.3	2.1	0.5
6	2.5	4.4	7.4	11.5	17.4	21.2	17.8	9.5	5.3	2.4	0.6
7	2.4	3.4	4.4	6.8	11.7	17.8	22.1	18.2	9.1	3.5	0.6
8	1.5	2.2	2.8	4.4	6.1	10.6	18.3	27.4	19.1	7.1	0.6
9	1.6	1.3	1.8	2.2	3.6	5.6	10.7	20.0	35.0	17.6	0.5
10	1.4	1.2	1.2	1.4	2.1	2.4	4.3	7.3	19.4	58.3	1.1
Ent	11.7	8.0	8.0	8.8	8.0	8.0	7.7	8.0	9.5	22.5	0.0

Table A.15: Transition T= t to T= $t+1$,ind= All, type= SR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	63.3	20.2	6.4	2.7	1.5	1.1	0.7	0.5	0.6	0.7	2.3
2	19.2	42.7	21.6	7.2	3.5	1.8	1.1	0.5	0.6	0.6	1.1
3	6.6	20.0	36.6	22.1	7.3	3.0	1.7	0.9	0.4	0.6	0.8
4	3.6	7.8	20.1	33.9	20.1	7.8	2.9	1.5	0.9	0.4	0.9
5	1.8	3.4	7.8	19.9	33.2	21.5	6.7	2.8	1.2	0.7	0.9
6	1.1	2.1	3.5	7.6	21.2	34.1	19.9	6.6	2.3	1.0	0.7
7	0.8	1.1	1.9	3.0	8.1	19.9	38.5	19.3	5.3	1.6	0.7
8	0.5	0.7	1.0	1.4	3.0	6.9	20.7	43.6	18.1	3.3	0.9
9	0.4	0.5	0.5	0.7	1.2	2.0	5.9	19.8	53.7	14.4	0.8
10	0.5	0.4	0.4	0.5	0.7	1.0	1.9	3.7	15.5	74.3	1.1
Ent	11.2	7.1	7.9	6.9	6.6	7.9	9.4	9.6	10.4	23.1	0.0

Table A.16: Transition T= t to T= $t+1$,ind= All, type= CSR

	1	2	3	4	5	6	7	8	9	10	Ex.
1	58.8	20.0	6.8	3.8	2.1	1.5	1.0	1.1	0.9	1.5	2.5
2	18.7	39.5	21.9	8.0	4.0	2.5	1.4	1.2	0.7	1.0	1.2
3	7.8	20.4	31.0	20.5	9.3	4.5	2.3	1.3	1.2	1.1	0.8
4	3.5	8.5	19.2	29.2	19.4	10.0	4.3	2.1	1.7	1.2	0.8
5	2.5	4.2	9.2	19.0	27.6	19.2	9.4	4.8	2.2	1.2	0.6
6	1.4	2.9	4.6	9.0	19.2	28.7	19.7	8.3	3.9	1.8	0.6
7	1.0	1.7	2.6	4.1	10.2	18.8	29.6	20.1	8.0	3.2	0.8
8	1.0	0.8	1.4	2.7	4.5	8.6	20.6	33.4	19.9	6.5	0.8
9	0.7	0.6	1.0	1.8	2.1	4.3	7.9	21.4	42.2	17.1	0.8
10	1.1	0.8	1.2	1.3	1.6	1.7	2.9	5.9	18.8	63.5	1.3
Ent	16.2	12.7	10.2	5.6	6.6	8.6	8.1	9.4	8.4	14.2	0.0

Table A.17: Transition T= t to T= $t+5$,ind= All, type= CD

	1	2	3	4	5	6	7	8	9	10
1	25.7	13.7	11.7	7.5	6.9	6.1	5.8	5.2	6.7	10.7
2	17.7	17.5	15.5	11.4	8.7	8.0	5.8	5.4	5.0	5.0
3	12.2	17.6	16.1	13.5	10.2	8.1	8.0	5.7	4.2	4.4
4	9.3	12.4	14.7	15.1	12.6	9.5	9.7	7.0	5.3	4.3
5	8.4	11.6	10.8	13.3	14.1	12.6	10.5	8.9	5.7	4.1
6	7.8	9.3	10.0	12.4	13.3	14.5	11.9	10.7	6.1	4.0
7	6.4	7.1	8.6	11.0	12.2	14.6	13.2	12.5	9.1	5.2
8	5.1	5.8	7.3	8.0	10.0	12.5	15.0	15.1	14.1	7.1
9	4.5	4.0	5.1	6.5	8.7	10.1	12.7	16.7	19.6	12.2
10	4.4	2.6	3.8	3.8	5.5	6.7	9.1	12.8	21.7	29.6

Table A.18: Transition T= $(t+1)^5$,ind= All, type= CD

	1	2	3	4	5	6	7	8	9	10
1	16.6	14.1	12.4	11.0	10.0	8.9	8.0	7.1	6.4	5.6
2	14.3	13.2	12.2	11.3	10.5	9.6	8.6	7.8	6.9	5.7
3	12.7	12.4	11.9	11.3	10.7	10.0	9.1	8.3	7.4	6.1
4	11.4	11.6	11.5	11.2	10.8	10.3	9.6	8.9	8.0	6.6
5	10.4	10.8	11.0	10.9	10.8	10.5	10.0	9.5	8.7	7.3
6	9.5	10.2	10.5	10.7	10.7	10.7	10.4	10.0	9.4	7.9
7	8.6	9.3	9.8	10.2	10.5	10.7	10.7	10.7	10.3	9.2
8	7.8	8.5	9.1	9.5	10.0	10.5	10.9	11.3	11.5	10.8
9	6.8	7.4	8.1	8.6	9.3	10.1	11.0	11.9	13.0	13.7
10	6.0	6.3	6.9	7.3	8.1	9.1	10.4	12.2	14.9	18.8

Table A.19: Transition T= t to T= $t+5$,ind= All, type= CSR

	1	2	3	4	5	6	7	8	9	10
1	33.8	17.0	11.2	7.5	6.1	5.1	3.9	4.0	4.3	6.9
2	19.8	22.3	16.6	12.1	7.5	6.1	4.4	3.8	2.8	4.6
3	12.3	17.8	18.9	16.1	10.6	7.4	6.0	4.1	3.1	3.7
4	7.8	12.9	15.4	16.7	14.2	11.2	8.1	5.5	4.1	4.1
5	5.9	9.6	11.7	13.7	15.2	13.6	12.2	8.2	5.5	4.3
6	4.3	6.8	9.5	12.7	13.8	14.8	13.7	11.4	8.4	4.6
7	3.1	4.4	6.7	8.9	13.0	15.0	17.2	13.9	10.9	7.0
8	2.4	3.9	4.4	6.9	10.4	13.1	15.3	17.9	15.8	9.9
9	2.9	2.6	4.0	4.4	7.0	9.9	13.7	18.[illegible]	21.9	14.8
10	2.7	2.2	2.8	3.6	4.7	5.7	7.3	13.4	24.5	33.3

Table A.20: Transition T= $(t+1)^5$,ind= All, type= CSR

	1	2	3	4	5	6	7	8	9	10
1	20.4	17.0	13.6	11.1	9.0	7.5	6.2	5.5	4.9	4.8
2	16.7	15.7	13.8	11.9	10.1	8.6	7.1	6.1	5.2	4.8
3	13.6	13.9	13.2	12.2	10.9	9.7	8.2	7.1	6.0	5.2
4	11.0	12.1	12.2	12.1	11.5	10.6	9.4	8.3	7.0	5.9
5	9.1	10.4	11.1	11.5	11.6	11.3	10.5	9.5	8.2	6.8
6	7.5	8.9	9.8	10.7	11.4	11.6	11.4	10.8	9.7	8.1
7	6.2	7.4	8.5	9.7	10.8	11.6	12.1	12.1	11.5	10.0
8	5.2	6.2	7.3	8.5	9.9	11.1	12.3	13.3	13.6	12.8
9	4.4	5.2	6.2	7.3	8.7	10.1	11.9	13.9	15.7	16.5
10	4.2	4.6	5.4	6.1	7.3	8.6	10.6	13.4	17.6	22.3

Table A.21: Productivity Rankings by SIC, Ind=35

		type=CSR			type=CD		
SIC	nobs	**Lo30**	**Mid.**	**Hi30**	**Lo30**	**Mid.**	**Hi30**
3511	311	26.4	46.3	27.3	30.5	38.6	30.9
3519	769	29.1	40.4	30.4	26.1	48.1	25.7
3523	1114	26.2	46.5	27.3	29.4	43.8	26.8
3524	430	32.1	34.4	33.5	24.9	50.7	24.4
3531	1696	29.9	43.2	26.9	25.4	46.0	28.7
3532	439	30.1	37.4	32.6	26.9	40.5	32.6
3533	977	31.4	33.2	35.4	36.0	27.6	36.3
3534	168	30.4	38.7	31.0	41.1	26.8	32.1
3535	450	23.3	51.3	25.3	25.8	49.3	24.9
3536	202	21.3	60.9	17.8	29.2	47.5	23.3
3537	368	33.4	34.8	31.8	27.2	42.9	29.9
3541	823	25.6	48.2	26.1	27.1	41.9	31.0
3542	391	29.2	43.5	27.4	28.1	41.0	29.9
3544	319	33.5	38.6	27.9	36.1	34.8	29.2
3545	698	27.7	44.3	28.1	34.7	34.5	30.8
3546	393	33.3	33.1	33.6	34.1	34.1	31.8
3547	130	30.0	40.0	30.0	42.3	26.2	31.5
3549	163	36.8	33.1	30.1	27.6	44.2	28.2
3551	304	24.3	41.4	34.2	25.0	48.7	26.3
3552	266	28.2	45.1	26.7	31.2	38.0	30.8
3553	66	37.9	33.3	28.8	21.2	48.5	30.3
3554	278	22.7	54.3	23.0	25.2	46.0	28.8
3555	347	28.0	42.4	29.7	29.4	38.9	31.7
3559	856	30.5	41.0	28.5	30.8	40.5	28.6
3561	1253	25.5	49.3	25.1	26.6	46.4	27.1
3562	808	31.6	40.2	28.2	27.8	45.2	27.0
3563	409	29.6	40.1	30.3	24.4	49.4	26.2
3564	482	25.3	46.5	28.2	28.4	47.5	24.1
3566	391	26.3	54.0	19.7	21.7	54.2	24.0
3567	242	28.9	44.6	26.4	26.9	53.7	19.4
3568	610	19.2	64.9	15.9	19.8	57.8	22.4
3569	510	29.4	42.9	27.6	26.9	47.5	25.7
3573	2062	41.1	12.6	46.3	43.3	9.8	46.9
3574	175	41.1	19.4	39.4	40.6	21.7	37.7
3576	152	31.6	36.2	32.2	32.2	41.4	26.3
3579	451	27.9	44.3	27.7	36.8	28.2	35.0
3581	179	23.5	53.1	23.5	24.0	54.7	21.2
3582	54	18.5	53.7	27.8	22.2	59.3	18.5
3585	1958	32.8	36.0	31.2	29.1	43.6	27.4
3586	147	35.4	36.7	27.9	28.6	46.3	25.2
3589	302	25.5	49.7	24.8	27.2	50.3	22.5
3592	470	31.1	41.3	27.7	30.9	38.1	31.1
3599	231	28.6	37.2	34.2	34.6	37.2	28.1
Avg.	—	29.2	42.0	28.8	29.5	42.1	28.4

Table A.22: Productivity Rankings by SIC, Ind=36

		type=CSR			type=CD		
SIC	nobs	Lo30	Mid.	Hi30	Lo30	Mid.	Hi30
3612	666	26.6	44.3	29.1	22.4	50.8	26.9
3613	1153	32.2	36.9	30.9	31.7	37.3	31.0
3621	1679	33.1	37.9	29.1	26.6	43.1	30.4
3622	683	29.6	39.4	31.0	32.1	37.2	30.7
3623	237	35.0	32.1	32.9	22.4	53.2	24.5
3624	232	26.7	44.8	28.4	25.9	43.1	31.0
3629	205	24.4	45.9	29.8	33.7	46.3	20.0
3631	447	29.3	41.8	28.9	28.2	47.2	24.6
3632	210	21.9	61.0	17.1	21.9	52.9	25.2
3633	187	19.3	60.4	20.3	28.3	39.6	32.1
3634	906	29.1	40.2	30.7	29.6	40.8	29.6
3635	118	38.1	30.5	31.4	36.4	33.9	29.7
3636	74	44.6	27.0	28.4	45.9	10.8	43.2
3639	247	24.7	48.6	26.7	22.3	[illegible]	17.8
3641	593	23.6	54.0	22.4	27.0	37.4	35.6
3643	711	21.4	53.9	24.8	26.9	43.0	30.1
3644	445	28.8	40.2	31.0	22.9	52.6	24.5
3645	279	32.6	32.3	35.1	27.2	43.0	29.7
3646	267	30.3	43.4	26.2	25.8	52.1	22.1
3647	145	33.1	38.6	28.3	24.1	47.6	28.3
3648	177	27.1	50.8	22.0	19.8	53.1	27.1
3651	646	39.9	21.1	39.0	37.9	25.5	36.5
3652	186	32.8	40.9	26.3	51.1	22.0	26.9
3661	857	31.6	38.4	30.0	29.2	41.2	29.6
3662	3295	28.4	36.9	34.7	32.0	37.4	30.6
3671	416	34.6	32.7	32.7	26.7	41.1	32.2
3672	.	.	.	.	.	.	.
3673	26	23.1	46.2	30.8	38.5	34.6	26.9
3674	1143	38.6	28.5	32.9	42.4	19.8	37.8
3675	492	24.2	52.0	23.8	29.3	40.9	29.9
3676	357	23.8	49.9	26.3	26.9	42.9	30.3
3677	295	35.3	31.9	32.9	35.9	33.9	30.2
3678	637	32.3	36.9	30.8	34.1	40.5	25.4
3679	1414	30.6	40.5	28.9	32.0	38.6	29.4
3691	706	21.5	57.2	21.2	21.2	56.1	22.7
3692	271	31.0	41.3	27.7	31.7	35.8	32.5
3693	310	31.0	35.5	33.5	39.4	30.6	30.0
3694	453	32.7	35.3	32.0	27.2	41.3	31.6
3699	212	31.1	48.6	20.3	27.8	41.0	31.1
Avg.	—	29.9	42.2	29.6	30.2	40.7	29.2

Table A.23: Productivity Rankings by SIC, Ind=38

		type=CSR			type=CD		
SIC	**nobs**	**Lo30**	**Mid.**	**Hi30**	**Lo30**	**Mid.**	**Hi30**
3811	488	23.6	46.7	29.7	29.9	40.8	29.3
3822	374	23.0	59.4	17.6	24.3	51.6	24.1
3823	413	28.8	38.0	33.2	25.9	43.1	31.0
3824	274	33.6	37.6	28.8	24.8	49.3	25.9
3825	802	29.1	41.3	29.7	27.7	41.1	31.2
3829	345	29.0	43.8	27.2	31.3	41.2	27.5
3832	513	32.7	40.4	26.9	33.9	34.3	31.8
3841	633	32.5	35.4	32.1	32.4	31.8	35.9
3842	683	30.9	38.1	31.0	32.7	38.1	29.3
3843	263	31.2	24.7	44.1	28.9	43.3	27.8
3851	346	30.9	41.9	27.2	35.0	40.8	24.3
3861	633	32.4	36.0	31.6	34.8	32.9	32.4
3873	321	30.5	37.7	31.8	23.1	48.9	28.0
Avg.	—	29.9	40.1	30.1	29.6	41.3	29.1

Table A.24: Tabulation, type= CD, ind=35

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	169	17.5	74.5	8.0	0.0
73, 5 < age <= 15	274	15.0	69.7	15.3	0.0
73, age > 15	965	19.3	63.7	17.0	0.0
74, age <= 5	138	14.8	70.4	14.8	0.0
74, 5 < age <= 15	281	16.7	64.4	18.9	0.0
74, age > 15	955	17.2	64.6	18.2	0.0
75, age <= 5	118	22.1	60.0	17.9	0.0
75, 5 < age <= 15	315	17.1	63.8	19.0	0.0
75, age > 15	997	19.8	61.1	19.2	0.0
76, age <= 5	102	17.6	57.6	24.7	0.0
76, 5 < age <= 15	320	12.8	70.9	16.3	0.0
76, age > 15	1042	19.7	63.3	17.0	0.0
77, age <= 5	106	13.6	62.1	24.2	0.0
77, 5 < age <= 15	386	16.6	59.6	19.7	4.1
77, age > 15	1093	17.8	63.6	17.1	1.5
78, age <= 5	90	16.4	55.2	28.4	0.0
78, 5 < age <= 15	395	14.4	64.3	19.5	1.8
78, age > 15	1153	17.1	66.8	15.4	0.8
79, age <= 5	77	32.8	36.2	31.0	0.0
79, 5 < age <= 15	389	14.4	59.6	23.7	2.3
79, age > 15	1173	18.0	67.6	12.7	1.7
80, age <= 5	82	15.4	50.8	33.8	0.0
80, 5 < age <= 15	369	20.6	49.6	28.2	1.6
80, age > 15	1175	21.1	63.1	15.4	0.4
81, age <= 5	64	20.0	56.4	23.6	0.0
81, 5 < age <= 15	339	19.2	56.3	22.4	2.1
81, age > 15	1183	18.3	65.7	14.9	1.1
82, age <= 5	113	16.1	58.9	25.0	0.0
82, 5 < age <= 15	316	18.4	62.3	15.8	3.5
82, age > 15	1203	21.4	59.8	16.9	2.0
83, age <= 5	62	17.7	64.5	17.7	0.0
83, 5 < age <= 15	270	14.4	67.4	15.9	2.2
83, age > 15	1183	18.8	61.9	16.1	3.3
84, age <= 5	41	14.6	80.5	4.9	0.0
84, 5 < age <= 15	238	10.1	64.3	14.3	11.3
84, age > 15	1174	14.0	61.9	14.2	9.9
85, age <= 5	37	21.6	73.0	5.4	0.0
85, 5 < age <= 15	182	9.3	72.5	14.3	3.8
85, age > 15	1059	14.7	68.1	13.6	3.6
86, age <= 5	25	4.0	80.0	16.0	0.0
86, 5 < age <= 15	149	14.8	57.0	15.4	12.8
86, age > 15	965	14.5	65.7	14.0	5.8

Table A.25: Tabulation, type= rtfp, ind=35

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	170	12.3	76.8	10.9	0.0
73, 5 < age <= 15	275	10.5	81.1	8.4	0.0
73, age > 15	966	10.5	78.7	10.9	0.0
74, age <= 5	138	12.0	74.1	13.9	0.0
74, 5 < age <= 15	282	9.2	75.5	15.2	0.0
74, age > 15	955	12.1	76.2	11.6	0.0
75, age <= 5	118	18.9	67.4	13.7	0.0
75, 5 < age <= 15	317	12.9	71.6	15.5	0.0
75, age > 15	997	14.8	73.2	11.9	0.0
76, age <= 5	104	27.6	56.3	16.1	0.0
76, 5 < age <= 15	322	10.2	74.8	14.9	0.0
76, age > 15	1042	12.2	75.0	12.8	0.0
77, age <= 5	106	22.7	54.5	22.7	0.0
77, 5 < age <= 15	386	10.9	66.1	18.9	4.1
77, age > 15	1093	12.2	74.3	12.1	1.5
78, age <= 5	93	22.9	51.4	25.7	0.0
78, 5 < age <= 15	395	13.9	66.8	17.5	1.8
78, age > 15	1153	12.7	75.3	11.2	0.8
79, age <= 5	77	27.6	51.7	20.7	0.0
79, 5 < age <= 15	389	11.1	67.1	19.5	2.3
79, age > 15	1173	12.8	76.0	9.5	1.7
80, age <= 5	82	18.5	50.8	30.8	0.0
80, 5 < age <= 15	371	16.2	62.3	19.9	1.6
80, age > 15	1178	13.7	74.4	11.5	0.4
81, age <= 5	65	16.1	62.5	21.4	0.0
81, 5 < age <= 15	340	11.5	70.9	15.6	2.1
81, age > 15	1185	12.9	75.8	10.2	1.1
82, age <= 5	113	21.4	60.7	17.9	0.0
82, 5 < age <= 15	316	15.2	67.4	13.9	3.5
82, age > 15	1204	15.9	67.5	14.6	2.0
83, age <= 5	62	14.5	69.4	16.1	0.0
83, 5 < age <= 15	270	10.7	71.5	15.6	2.2
83, age > 15	1184	13.9	68.7	14.1	3.3
84, age <= 5	41	14.6	63.4	22.0	0.0
84, 5 < age <= 15	238	11.3	65.5	11.8	11.3
84, age > 15	1175	11.1	66.6	12.4	9.9
85, age <= 5	37	13.5	67.6	18.9	0.0
85, 5 < age <= 15	182	11.0	70.3	14.8	3.8
85, age > 15	1060	11.0	74.2	11.1	3.6
86, age <= 5	25	16.0	68.0	16.0	0.0
86, 5 < age <= 15	149	15.4	55.7	16.1	12.8
86, age > 15	965	10.7	71.1	12.4	5.8

Table A.26: Tabulation, type= CD, ind=36

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	186	14.4	66.7	19.0	0.0
73, 5 < age <= 15	363	16.8	66.4	16.8	0.0
73, age > 15	750	16.1	71.2	12.7	0.0
74, age <= 5	159	22.8	59.8	17.3	0.0
74, 5 < age <= 15	364	20.3	63.5	16.2	0.0
74, age > 15	759	15.7	68.9	15.4	0.0
75, age <= 5	119	21.6	51.0	27.5	0.0
75, 5 < age <= 15	375	18.1	60.3	21.6	0.0
75, age > 15	819	21.5	60.4	18.1	0.0
76, age <= 5	132	16.2	61.9	21.9	0.0
76, 5 < age <= 15	370	18.9	65.9	15.1	0.0
76, age > 15	866	15.0	68.1	16.9	0.0
77, age <= 5	96	17.9	50.0	30.4	1.8
77, 5 < age <= 15	429	14.5	61.3	21.4	2.8
77, age > 15	929	17.2	65.8	14.7	2.3
78, age <= 5	89	20.3	53.1	26.6	0.0
78, 5 < age <= 15	428	19.9	61.2	17.8	1.2
78, age > 15	958	18.3	65.4	15.3	0.9
79, age <= 5	78	13.0	63.0	24.1	0.0
79, 5 < age <= 15	414	20.0	62.6	13.8	3.6
79, age > 15	960	15.7	67.2	14.7	2.4
80, age <= 5	80	20.0	64.6	15.4	0.0
80, 5 < age <= 15	378	19.6	56.1	22.8	1.6
80, age > 15	980	18.2	66.4	14.9	0.5
81, age <= 5	68	10.5	70.2	19.3	0.0
81, 5 < age <= 15	340	19.7	59.7	17.9	2.6
81, age > 15	1028	16.8	64.4	16.9	1.8
82, age <= 5	153	21.4	53.6	25.0	0.0
82, 5 < age <= 15	324	13.6	64.8	17.9	3.7
82, age > 15	1042	18.1	65.8	14.7	1.3
83, age <= 5	86	14.0	61.6	24.4	0.0
83, 5 < age <= 15	307	22.8	60.6	13.7	2.9
83, age > 15	1032	17.3	63.1	16.8	2.8
84, age <= 5	69	23.2	66.7	10.1	0.0
84, 5 < age <= 15	282	17.4	56.0	15.6	11.0
84, age > 15	1068	13.5	66.4	12.7	7.4
85, age <= 5	83	19.3	67.5	13.3	0.0
85, 5 < age <= 15	240	17.5	65.8	11.3	5.4
85, age > 15	986	13.6	70.0	12.7	3.8
86, age <= 5	72	13.9	69.4	16.7	0.0
86, 5 < age <= 15	194	19.6	64.9	11.3	4.1
86, age > 15	918	14.6	68.2	12.4	4.8

Table A.27: Tabulation, type= CSR, ind=36

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	189	12.2	70.5	17.3	0.0
73, 5 < age <= 15	364	9.6	75.8	14.6	0.0
73, age > 15	753	10.9	80.9	8.2	0.0
74, age <= 5	161	14.7	64.3	20.9	0.0
74, 5 < age <= 15	365	9.9	74.5	15.6	0.0
74, age > 15	761	12.6	77.5	9.9	0.0
75, age <= 5	122	21.0	59.0	20.0	0.0
75, 5 < age <= 15	375	13.9	65.6	20.5	0.0
75, age > 15	820	13.4	74.5	12.1	0.0
76, age <= 5	133	18.9	61.3	19.8	0.0
76, 5 < age <= 15	370	15.1	71.6	13.2	0.0
76, age > 15	867	11.1	78.8	10.1	0.0
77, age <= 5	98	15.5	58.6	24.1	1.7
77, 5 < age <= 15	430	14.0	67.0	16.3	2.8
77, age > 15	931	9.2	79.6	8.9	2.3
78, age <= 5	92	16.4	67.2	16.4	0.0
78, 5 < age <= 15	429	13.5	69.7	15.4	1.2
78, age > 15	962	11.7	77.9	9.5	0.9
79, age <= 5	78	14.8	63.0	22.2	0.0
79, 5 < age <= 15	418	13.9	69.9	12.7	3.6
79, age > 15	964	10.2	76.7	10.8	2.4
80, age <= 5	81	13.6	66.7	19.7	0.0
80, 5 < age <= 15	381	17.6	67.7	13.1	1.6
80, age > 15	986	11.9	76.6	11.1	0.5
81, age <= 5	68	8.8	75.4	15.8	0.0
81, 5 < age <= 15	342	11.1	71.1	15.2	2.6
81, age > 15	1030	13.2	75.0	10.0	1.8
82, age <= 5	153	14.3	69.6	16.1	0.0
82, 5 < age <= 15	324	10.8	72.2	13.3	3.7
82, age > 15	1042	12.5	73.0	13.1	1.3
83, age <= 5	86	9.3	73.3	17.4	0.0
83, 5 < age <= 15	307	15.3	67.4	14.3	2.9
83, age > 15	1033	12.0	75.1	10.1	2.8
84, age <= 5	69	18.8	62.3	18.8	0.0
84, 5 < age <= 15	284	14.8	62.7	11.6	10.9
84, age > 15	1070	10.7	71.4	10.6	7.4
85, age <= 5	83	24.1	66.3	9.6	0.0
85, 5 < age <= 15	241	15.4	63.9	15.4	5.4
85, age > 15	991	11.2	73.4	11.7	3.7
86, age <= 5	72	16.7	72.2	11.1	0.0
86, 5 < age <= 15	196	17.3	65.8	12.8	4.1
86, age > 15	921	11.5	74.3	9.4	4.8

Table A.28: Tabulation, type= CD, ind=38

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	55	19.6	60.9	19.6	0.0
73, 5 < age <= 15	92	20.7	63.0	16.3	0.0
73, age > 15	207	17.4	65.2	17.4	0.0
74, age <= 5	45	22.5	52.5	25.0	0.0
74, 5 < age <= 15	93	25.8	59.1	15.1	0.0
74, age > 15	201	21.4	59.2	19.4	0.0
75, age <= 5	48	22.2	52.8	25.0	0.0
75, 5 < age <= 15	104	18.3	62.5	19.2	0.0
75, age > 15	215	20.0	63.3	16.7	0.0
76, age <= 5	32	30.8	57.7	11.5	0.0
76, 5 < age <= 15	117	14.5	62.4	23.1	0.0
76, age > 15	230	14.8	68.3	17.0	0.0
77, age <= 5	26	8.3	83.3	8.3	0.0
77, 5 < age <= 15	145	19.3	60.7	17.2	2.8
77, age > 15	247	17.8	66.4	13.8	2.0
78, age <= 5	26	20.0	65.0	15.0	0.0
78, 5 < age <= 15	142	17.6	65.5	14.8	2.1
78, age > 15	258	16.7	66.3	16.3	0.8
79, age <= 5	23	16.7	72.2	11.1	0.0
79, 5 < age <= 15	132	18.2	60.6	18.9	2.3
79, age > 15	262	18.3	66.8	13.7	1.1
80, age <= 5	25	21.7	73.9	4.3	0.0
80, 5 < age <= 15	126	23.8	58.7	16.7	0.8
80, age > 15	261	18.0	64.0	17.2	0.8
81, age <= 5	23	11.1	77.8	11.1	0.0
81, 5 < age <= 15	127	17.3	64.6	13.4	4.7
81, age > 15	262	17.6	63.7	17.9	0.8
82, age <= 5	40	27.3	45.5	27.3	0.0
82, 5 < age <= 15	120	11.7	60.0	24.2	4.2
82, age > 15	274	22.6	63.9	12.0	1.5
83, age <= 5	21	14.3	47.6	38.1	0.0
83, 5 < age <= 15	98	19.4	65.3	12.2	3.1
83, age > 15	290	13.8	69.7	15.2	1.4
84, age <= 5	18	27.8	50.0	22.2	0.0
84, 5 < age <= 15	77	14.3	58.4	19.5	7.8
84, age > 15	304	15.1	64.5	15.1	5.3
85, age <= 5	24	16.7	79.2	4.2	0.0
85, 5 < age <= 15	60	16.7	70.0	10.0	3.3
85, age > 15	289	13.5	71.6	11.4	3.5
86, age <= 5	20	25.0	50.0	25.0	0.0
86, 5 < age <= 15	51	15.7	66.7	7.8	9.8
86, age > 15	282	13.5	69.9	10.3	6.4

Table A.29: Tabulation, type= CSR, ind=38

Year	nobs	Lose	Stay	Gain	Exit
73, age <= 5	189	12.2	70.5	17.3	0.0
73, 5 < age <= 15	364	9.6	75.8	14.6	0.0
73, age > 15	753	10.9	80.9	8.2	0.0
74, age <= 5	161	14.7	64.3	20.9	0.0
74, 5 < age <= 15	365	9.9	74.5	15.6	0.0
74, age > 15	761	12.6	77.5	9.9	0.0
75, age <= 5	122	21.0	59.0	20.0	0.0
75, 5 < age <= 15	375	13.9	65.6	20.5	0.0
75, age > 15	820	13.4	74.5	12.1	0.0
76, age <= 5	133	18.9	61.3	19.8	0.0
76, 5 < age <= 15	370	15.1	71.6	13.2	0.0
76, age > 15	867	11.1	78.8	10.1	0.0
77, age <= 5	98	15.5	58.6	24.1	1.7
77, 5 < age <= 15	430	14.0	67.0	16.3	2.8
77, age > 15	931	9.2	79.6	8.9	2.3
78, age <= 5	92	16.4	67.2	16.4	0.0
78, 5 < age <= 15	429	13.8	69.7	15.4	1.2
78, age > 15	962	11.7	77.9	9.5	0.9
79, age <= 5	78	14.8	63.0	22.2	0.0
79, 5 < age <= 15	418	13.9	69.9	12.7	3.6
79, age > 15	964	10.2	76.7	10.8	2.4
80, age <= 5	81	13.6	66.7	19.7	0.0
80, 5 < age <= 15	381	17.6	67.7	13.1	1.6
80, age > 15	986	11.9	76.6	11.1	0.5
81, age <= 5	68	8.8	75.4	15.8	0.0
81, 5 < age <= 15	342	11.1	71.1	15.2	2.6
81, age > 15	1030	13.2	75.0	10.0	1.8
82, age <= 5	153	14.3	69.6	16.1	0.0
82, 5 < age <= 15	324	10.8	72.2	13.3	3.7
82, age > 15	1042	12.5	73.0	13.1	1.3
83, age <= 5	86	9.3	73.3	17.4	0.0
83, 5 < age <= 15	307	15.3	67.4	14.3	2.9
83, age > 15	1033	12.0	75.1	10.1	2.8
84, age <= 5	69	18.8	62.3	18.8	0.0
84, 5 < age <= 15	284	14.8	62.7	11.6	10.9
84, age > 15	1070	10.7	71.4	10.6	7.4
85, age <= 5	83	24.1	66.3	9.6	0.0
85, 5 < age <= 15	241	15.4	63.9	15.4	5.4
85, age > 15	991	11.2	73.4	11.7	3.7
86, age <= 5	72	16.7	72.2	11.1	0.0
86, 5 < age <= 15	196	17.3	65.8	12.8	4.1
86, age > 15	921	11.5	74.3	9.4	4.8

Fig. A.1

Plants Size Distribution, Ind=35

Avg. over plant lifespan

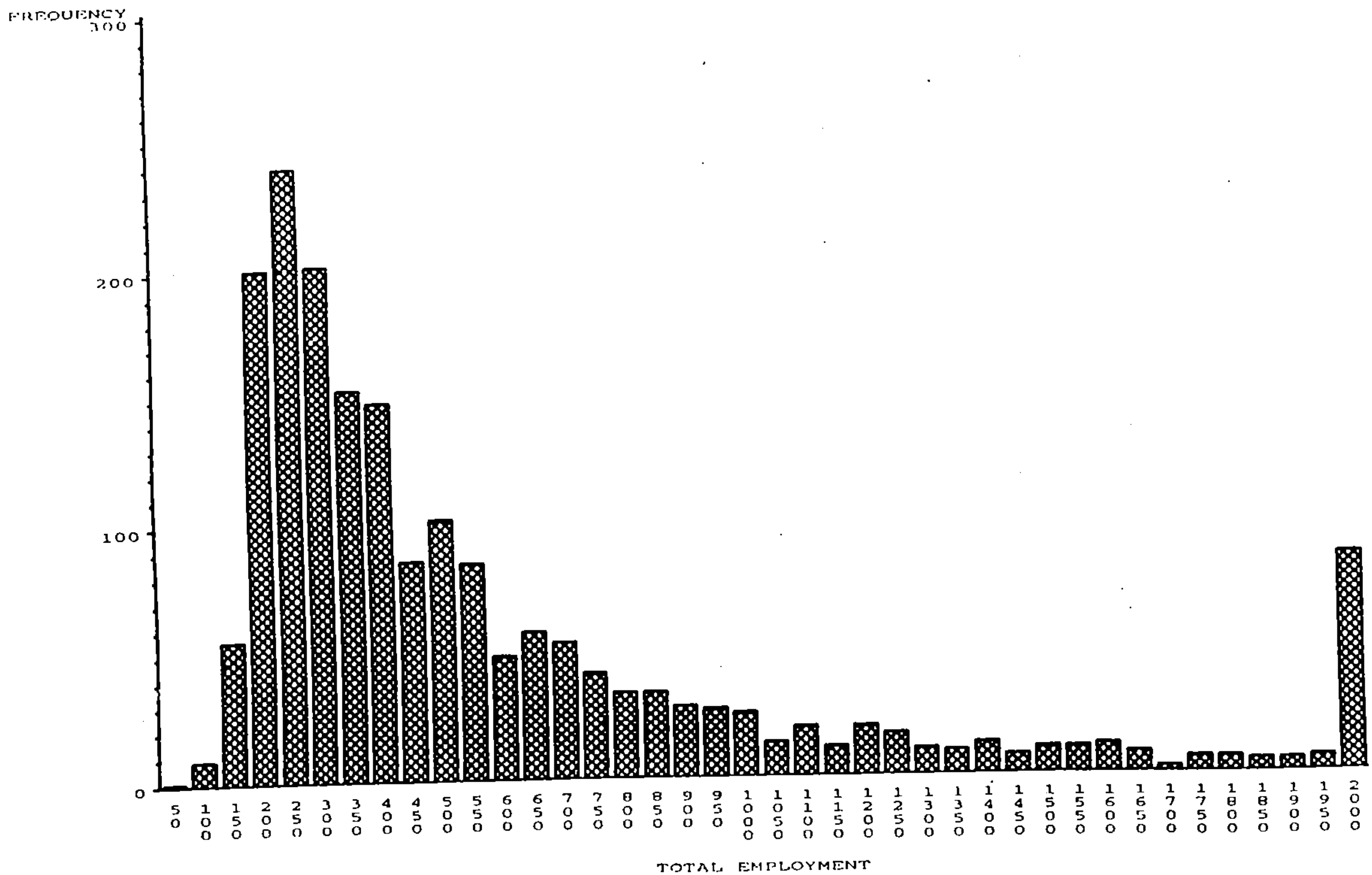

Fig. A.2

Plants Size Distribution, Ind=36

Avg. over plant lifespan

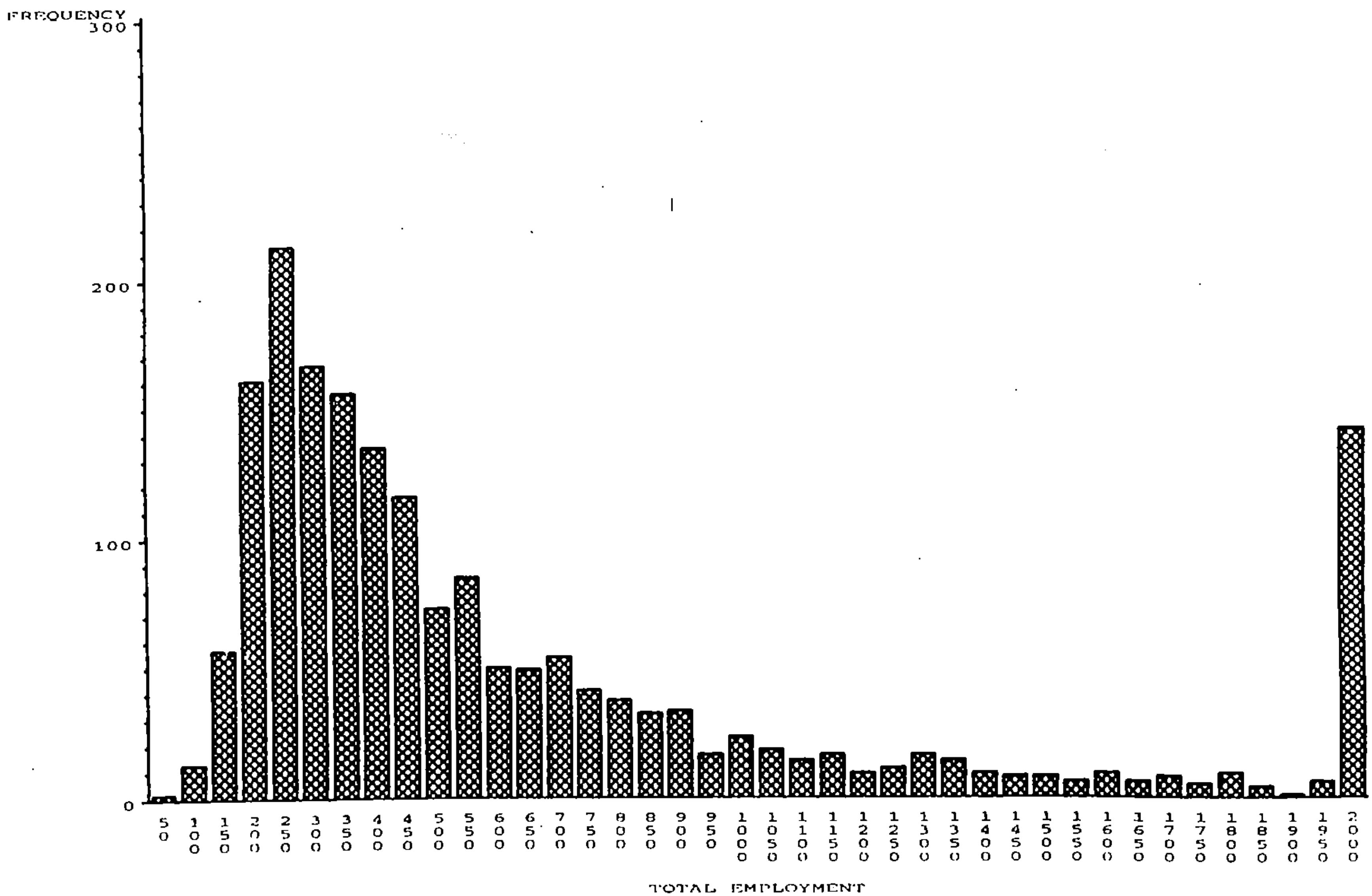

Fig. A.3

Plants Size Distribution, Ind=38

Avg. over plant lifespan

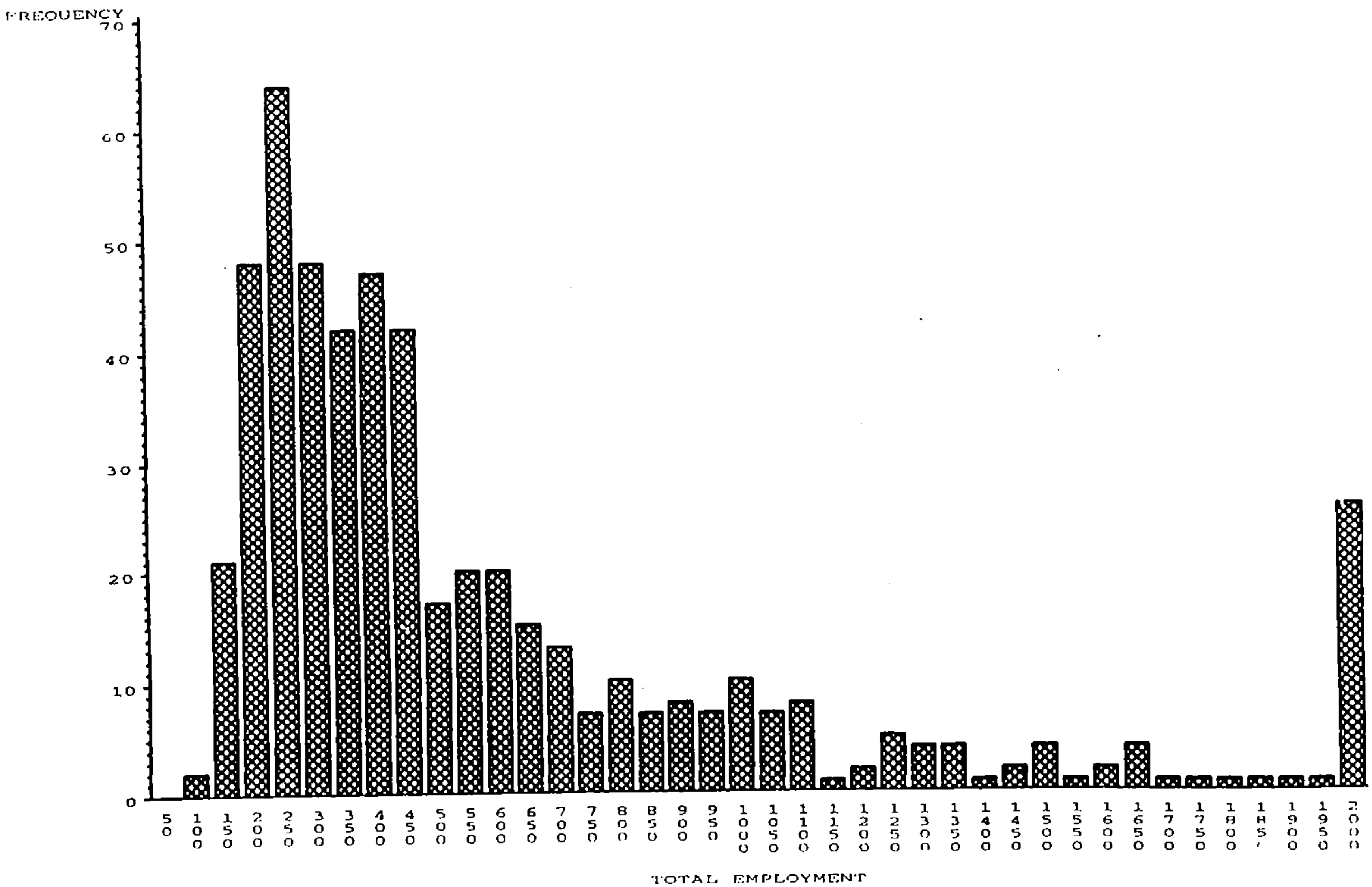

Fig. A4

Plants Size Distribution

Avg. over plant lifespan